SOIL SURVEY

Worth County Missouri

OUR SOIL ★ OUR STRENGTH

Issued October 1968

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
MISSOURI AGRICULTURAL EXPERIMENT STATION

Major fieldwork for this soil survey was done in the period 1958–62. Soil names and descriptions were approved in 1965. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1962. This survey was made cooperatively by the Soil Conservation Service and the Missouri Agricultural Experiment Station. It is part of the technical assistance furnished to the Worth County Soil and Water Conservation District.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY of Worth County contains information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, or other structures; and in judging the suitability of tracts of land for agriculture, industry, or recreation.

Locating Soils

All of the soils of Worth County are shown on the detailed map at the back of this survey. This map consists of many sheets that are made from aerial photographs. Each sheet is numbered to correspond with numbers shown on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information in the survey. This guide lists all of the soils of the county in alphabetic order by map symbol. It shows the page where each kind of soil is described, and also the page for the capability unit in which the soil has been placed.

Interpretations not included in the text can be developed by grouping the soils according to their suitability or limitations for a particular use. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils in the soil descriptions and in the discussions of the capability units.

Foresters and others can refer to the section "Woodland Uses of the Soils" for facts about woodland in the county.

Game managers, sportsmen, and others concerned with wildlife will find information about soils and wildlife in the section "Wildlife."

Engineers and builders will find, under "Engineering Uses of the Soils," tables that give engineering descriptions of the soils in the county and that name soil features that affect engineering practices and structures.

Scientists and others can read about how the soils were formed and how they are classified in the section "Genesis, Morphology, and Classification of Soils."

Newcomers in Worth County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "Additional Facts About the County."

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GUIDE TO MAPPING UNITS

[For a full description of a mapping unit, read both the description of the mapping unit and the description of the soil series to which it belongs.

[See table 1, page 5, for approximate acreage and proportionate extent of soils and table 2, page 27, for estimated average acre yields. For facts about woodland, see the section "Woodland Uses of the Soils" beginning on page 26. For information significant to engineering, see section beginning on page 30]

Map symbol	Mapping unit	Described on page	Capability unit	
			Symbol	Page
AaB2	Adair silt loam variant and Adair loam, 2 to 5 percent slopes, moderately eroded	7	IIe-6	23
AsC	Adair and Shelby loams, 5 to 9 percent slopes	7	IIIe-6	24
AsC2	Adair and Shelby loams, 5 to 9 percent slopes, moderately eroded	7	IIIe-6	24
AsC3	Adair and Shelby soils, 5 to 9 percent slopes, severely eroded	7	IVe-6	25
Au	Alluvial land	7	IIIw-1	24
EbA	Edina silt loam, benches, 0 to 3 percent slopes	9	IIw-1	24
GaD2	Gara loam, 9 to 14 percent slopes, moderately eroded	9	IVe-6	25
GaE2	Gara loam, 14 to 20 percent slopes, moderately eroded	9	VIe-6	25
GaF	Gara loam, 20 to 35 percent slopes	9	VIIe-6	25
GrF3	Gara soils, 20 to 35 percent slopes, severely eroded	10	VIIe-6	25
GsB	Grundy silt loam, 2 to 5 percent slopes	10	IIe-6	23
GsB2	Grundy silt loam, 2 to 5 percent slopes, moderately eroded	10	IIIe-6	24
GuA	Grundy silt loam, benches, 0 to 2 percent slopes	10	IIw-1	24
GuB	Grundy silt loam, benches, 2 to 5 percent slopes	11	IIe-6	23
GuC2	Grundy silt loam, benches, 5 to 9 percent slopes, moderately eroded	11	IIIe-6	24
Kc	Kennebec silt loam	11	I-1	23
KeC	Keswick loam, 5 to 9 percent slopes	12	IIIe-6	24
KeC2	Keswick loam, 5 to 9 percent slopes, moderately eroded	12	IIIe-6	24
KkC2	Keswick loam, valleys, 5 to 9 percent slopes, moderately eroded	12	IIIe-6	24
KkD2	Keswick loam, valleys, 9 to 14 percent slopes, moderately eroded	12	VIe-6	25
KsC3	Keswick soils, 5 to 9 percent slopes, severely eroded	13	IVe-6	25
KvC3	Keswick soils, valleys, 5 to 9 percent slopes, severely eroded	13	IVe-6	25
KvD3	Keswick soils, valleys, 9 to 14 percent slopes, severely eroded	13	VIe-6	25
LaB	Ladoga silt loam, 2 to 5 percent slopes	13	IIe-6	23
LaC2	Ladoga silt loam, 5 to 9 percent slopes, moderately eroded	13	IIIe-6	24
LaD2	Ladoga silt loam, 9 to 14 percent slopes, moderately eroded	13	IVe-6	25
LbB	Ladoga silt loam, benches, 2 to 5 percent slopes	14	IIe-6	23
LbC2	Ladoga silt loam, benches, 5 to 9 percent slopes, moderately eroded	14	IIIe-6	24
LcC	Lagonda and Clarinda soils, 5 to 11 percent slopes	14	IIIe-6	24
LcC2	Lagonda and Clarinda soils, 5 to 11 percent slopes, moderately eroded	15	IIIe-6	24
LcC3	Lagonda and Clarinda soils, 5 to 11 percent slopes, severely eroded	15	IVe-6	25
Ne	Nevin silt loam	16	IIw-1	24
No	Nodaway silt loam	16	I-1	23
Nw	Nodaway silt loam, overflow	16	IIIw-1	24
OaB	Olmitz loam, 2 to 5 percent slopes	17	IIe-1	23
OkB	Olmitz-Kennebec complex, 0 to 5 percent slopes	17	IIe-1	23
PeB	Pershing silt loam, 2 to 5 percent slopes	18	IIe-6	23
PeB2	Pershing silt loam, 2 to 5 percent slopes, moderately eroded	18	IIIe-6	24
PeC	Pershing silt loam, 5 to 9 percent slopes	18	IIIe-6	24
PeC2	Pershing silt loam, 5 to 9 percent slopes, moderately eroded	18	IIIe-6	24
PrB	Pershing silt loam, benches, 2 to 5 percent slopes	18	IIe-6	23
PrB2	Pershing silt loam, benches, 2 to 5 percent slopes, moderately eroded	18	IIIe-6	24
PrC2	Pershing silt loam, benches, 5 to 9 percent slopes, moderately eroded	18	IIIe-6	24
PsC3	Pershing and Grundy soils, benches, 5 to 9 percent slopes, severely eroded	18	IVe-6	25
SaB	Sharpsburg silt loam, 2 to 5 percent slopes	19	IIe-6	23
SaB2	Sharpsburg silt loam, 2 to 5 percent slopes, moderately eroded	19	IIe-6	23
SaC	Sharpsburg silt loam, 5 to 9 percent slopes	19	IIIe-6	24
SaC2	Sharpsburg silt loam, 5 to 9 percent slopes, moderately eroded	19	IIIe-6	24
SbC	Sharpsburg silt loam, benches, 3 to 8 percent slopes	19	IIe-6	23
SgC3	Sharpsburg soils, 5 to 9 percent slopes, severely eroded	20	IVe-6	25
ShD	Shelby loam, 9 to 14 percent slopes	20	IVe-6	25
ShD2	Shelby loam, 9 to 14 percent slopes, moderately eroded	20	IVe-6	25
ShE	Shelby loam, 14 to 20 percent slopes	20	VIe-6	25
ShE2	Shelby loam, 14 to 20 percent slopes, moderately eroded	20	VIe-6	25
ShF	Shelby loam, 20 to 30 percent slopes	20	VIIe-6	25
SrE3	Shelby and Gara soils, 9 to 20 percent slopes, severely eroded	21	VIe-6	25
Te	Terrace escarpments	21	VIe-6	25
Wa	Wabash silty clay	21	IIIw-14	24
Wb	Wabash silty clay loam	21	IIw-1	24

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SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, D, E, or F, shows the slope. Most symbols without a slope letter are those of nearly level soils or land types, but some are for land types that have a considerable range in slope. Soils that are named as moderately eroded or severely eroded have a final number, 2 or 3, in their symbol.

SYMBOL	NAME
AoB2	Adair silt loam variant and Adair loam, 2 to 5 percent slopes, moderately eroded
AsC	Adair and Shelby loams, 5 to 9 percent slopes
AsC2	Adair and Shelby loams, 5 to 9 percent slopes, moderately eroded
AsC3	Adair and Shelby soils, 5 to 9 percent slopes, severely eroded
Au	Alluvial land
EbA	Edina silt loam, benches, 0 to 3 percent slopes
GaD2	Gara loam, 9 to 14 percent slopes, moderately eroded
GaE2	Gara loam, 14 to 20 percent slopes, moderately eroded
GaF	Gara loam, 20 to 35 percent slopes
GrF3	Gara soils, 20 to 35 percent slopes, severely eroded
GsB	Grundy silt loam, 2 to 5 percent slopes
GsB2	Grundy silt loam, 2 to 5 percent slopes, moderately eroded
GuA	Grundy silt loam, benches, 0 to 2 percent slopes
GuB	Grundy silt loam, benches, 2 to 5 percent slopes
GuC2	Grundy silt loam, benches, 5 to 9 percent slopes, moderately eroded
Kc	Kennebec silt loam
KeC	Keswick loam, 5 to 9 percent slopes
KeC2	Keswick loam, 5 to 9 percent slopes, moderately eroded
KkC2	Keswick loam, valleys, 5 to 9 percent slopes, moderately eroded
KkD2	Keswick loam, valleys, 9 to 14 percent slopes, moderately eroded
KsC3	Keswick soils, 5 to 9 percent slopes, severely eroded
KvC3	Keswick soils, valleys, 5 to 9 percent slopes, severely eroded
KvD3	Keswick soils, valleys, 9 to 14 percent slopes, severely eroded
LaB	Ladoga silt loam, 2 to 5 percent slopes
LaC2	Ladoga silt loam, 5 to 9 percent slopes, moderately eroded
LaD2	Ladoga silt loam, 9 to 14 percent slopes, moderately eroded
LbB	Ladoga silt loam, benches, 2 to 5 percent slopes
LbC2	Ladoga silt loam, benches, 5 to 9 percent slopes, moderately eroded
LcC	Lagonda and Clarinda soils, 5 to 11 percent slopes
LcC2	Lagonda and Clarinda soils, 5 to 11 percent slopes, moderately eroded
LcC3	Lagonda and Clarinda soils, 5 to 11 percent slopes, severely eroded
Ne	Nevin silt loam
No	Nodaway silt loam
Nw	Nodaway silt loam, overflow
OaB	Olmitz loam, 2 to 5 percent slopes
OkB	Olmitz–Kennebec complex, 0 to 5 percent slopes
PeB	Pershing silt loam, 2 to 5 percent slopes
PeB2	Pershing silt loam, 2 to 5 percent slopes, moderately eroded
PeC	Pershing silt loam, 5 to 9 percent slopes
PeC2	Pershing silt loam, 5 to 9 percent slopes, moderately eroded
PrB	Pershing silt loam, benches, 2 to 5 percent slopes
PrB2	Pershing silt loam, benches, 2 to 5 percent slopes, moderately eroded
PrC2	Pershing silt loam, benches, 5 to 9 percent slopes, moderately eroded
PsC3	Pershing and Grundy soils, benches, 5 to 9 percent slopes, severely eroded
SaB	Sharpsburg silt loam, 2 to 5 percent slopes
SaB2	Sharpsburg silt loam, 2 to 5 percent slopes, moderately eroded
SaC	Sharpsburg silt loam, 5 to 9 percent slopes
SaC2	Sharpsburg silt loam, 5 to 9 percent slopes, moderately eroded
SbC	Sharpsburg silt loam, benches, 3 to 8 percent slopes
SgC3	Sharpsburg soils, 5 to 9 percent slopes, severely eroded
ShD	Shelby loam, 9 to 14 percent slopes
ShD2	Shelby loam, 9 to 14 percent slopes, moderately eroded
ShE	Shelby loam, 14 to 20 percent slopes
ShE2	Shelby loam, 14 to 20 percent slopes, moderately eroded
ShF	Shelby loam, 20 to 30 percent slopes
SrE3	Shelby and Gara soils, 9 to 20 percent slopes, severely eroded
Te	Terrace escarpments
Wa	Wabash silty clay
Wb	Wabash silty clay loam

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads
- Dual
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- U. S.
- State or county

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail, foot
- Railroad
- Ferry (FY)
- Ford (FORD)
- Grade
- R. R. over
- R. R. under
- Tunnel

Buildings
- School
- Church
- Station

Mines and Quarries

Mine dump

Pits, gravel or other

Power line

Pipeline

Cemetery

Dams

Levee

Tanks

Well, oil or gas

BOUNDARIES

- National or state
- County
- Reservation
- Land grant
- Small park, cemetery, airport
- Land survey division corners

DRAINAGE

Streams, double-line
- Perennial
- Intermittent

Streams, single-line
- Perennial
- Intermittent

Canals and ditches (CANAL)

Lakes and ponds
- Perennial (water) (w)
- Intermittent

Wells, water (flowing)

Spring

Marsh or swamp

Wet spot

Alluvial fan

Drainage end

RELIEF

Escarpments
- Bedrock
- Other

Prominent peak

Depressions (Large, Small)
- Crossable with tillage implements
- Not crossable with tillage implements
- Contains water most of the time

SOIL SURVEY DATA

- Soil boundary and symbol (Dx)
- Gravel
- Stony, very stony
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion
- Gully

Soil map constructed 1966 by Cartographic Division, Soil Conservation Service, USDA, from 1963 aerial photographs. Controlled mosaic based on Missouri plane coordinate system, west zone, transverse Mercator projection, 1927 North American datum.

SOIL SURVEY OF WORTH COUNTY, MISSOURI

BY BURTON L. BROWN, SOIL CONSERVATION SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

SOILS SURVEYED BY GALEN E. KITNER, JAMES P. ANDREWS, AND BURTON L. BROWN, SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE MISSOURI AGRICULTURAL EXPERIMENT STATION

WORTH COUNTY is in the northwestern part of Missouri (fig. 1). It is the smallest county in the State and has a total area of 170,880 acres. Grant City, the county seat, is near the center of the county. It had a population of 1,061 in 1960.[1] In the same year, the county had a population of 3,936.

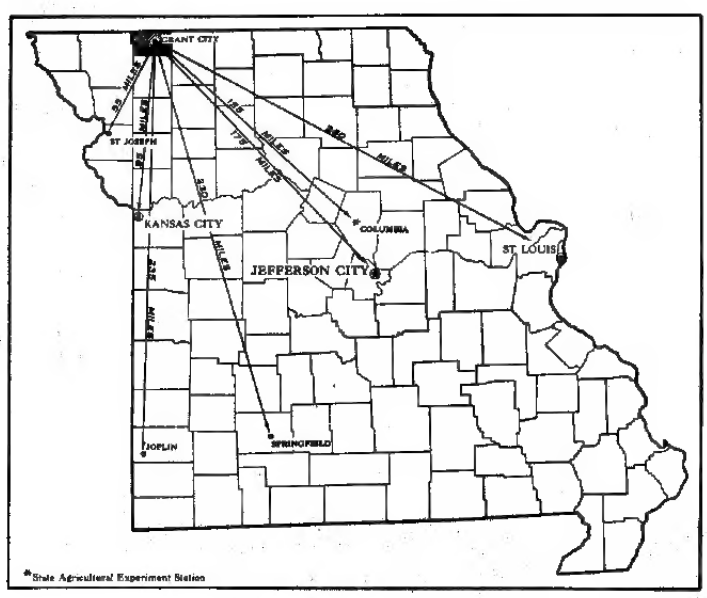

Figure 1.—**Location of Worth County in Missouri.**

Farming is the principal enterprise in the county. In 1959 slightly more than 93 percent of the land area was in farms, mainly cash-grain and livestock farms. The principal field crops are corn, soybeans, and oats, but alfalfa and other legumes and grasses are grown for hay or pasture. The principal kinds of livestock are cattle, hogs, and sheep.

Most of the soils have gentle to moderate slopes, and many of these sloping soils are eroded. Wetness is a hazard in about half of the acreage of bottom-land soils.

[1] Statistics used are from reports of the U.S. Bureau of the Census.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Worth County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect management.

Four soil associations are in Worth County. They are described in the following paragraphs.

1. Shelby-Lagonda-Sharpsburg Association

Sloping to hilly, moderately well drained or somewhat poorly drained soils that have developed in glacial till on side slopes and in loess on ridgetops

This soil association occupies most of the areas between streams in the western two-thirds of the county (fig. 2). It makes up about 49 percent of the total acreage in the county.

Shelby soils are more sloping than others in the association and occupy the largest area. They are loamy, moderately well drained soils that developed in glacial till. They have a subsoil of yellowish-brown clay loam.

The Lagonda are somewhat poorly drained soils near the heads of drainageways and on nearby side slopes. They have developed mainly in erosional sediment and glacial till, but to some extent in shallow loess. Their surface layer is generally silty. The lower part of their subsoil consists of grayish-brown silty clay that in a few places contains small amounts of gravel and coarse sand. The Lagonda soils are seepy and wet during rainy seasons and are subject to severe erosion if they are not protected. Their slopes range from 5 to 11 percent.

The Sharpsburg soils are gently sloping to moderately

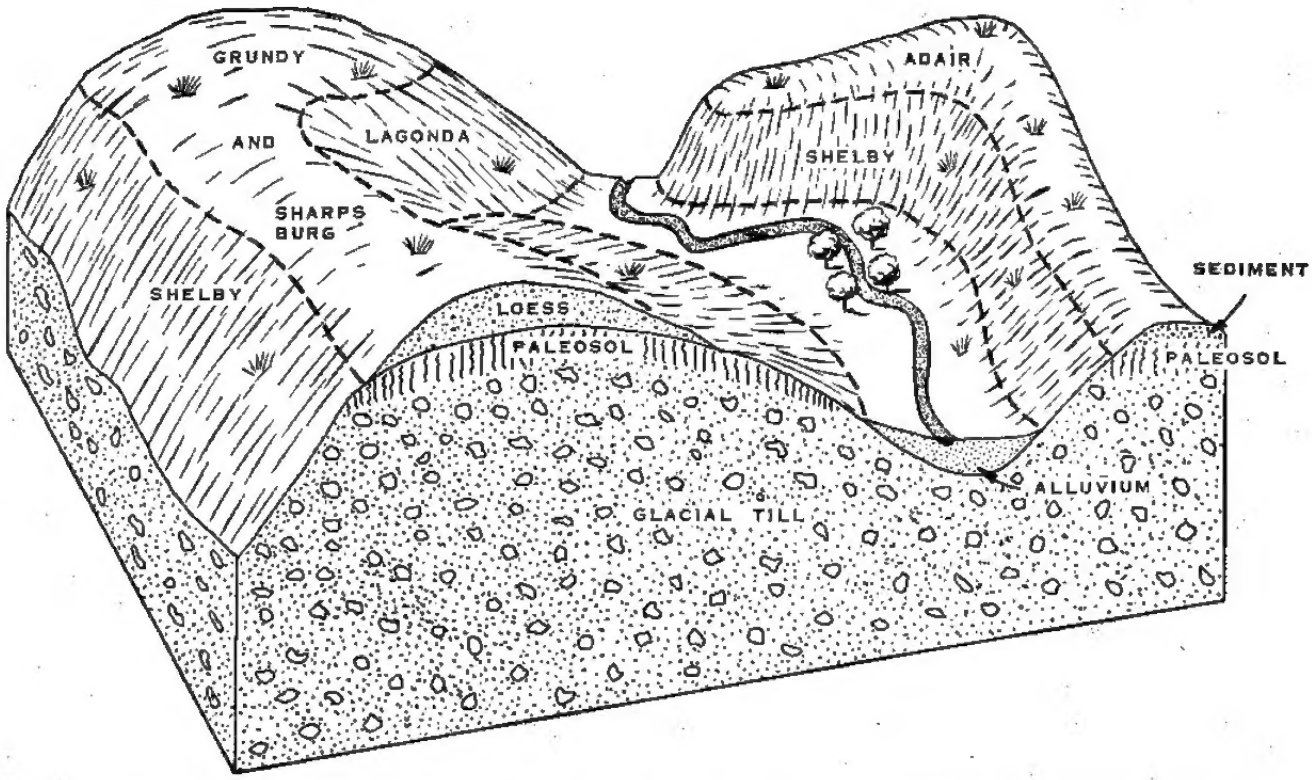

***Figure 2.*—Typical landscape in association 1 showing relationship of major soils and the underlying material. Some of the soils overlie a paleosol, or buried soil.**

sloping and are moderately well drained. They have developed in a layer of loess, 4 to 10 feet thick, on ridgetops, divides, and benches. Their subsoil is brown silty clay loam.

Moderately well drained Adair soils occupy a minor acreage below the Sharpsburg soils and above the Shelby. Well drained and moderately well drained Olmitz and Kennebec soils occupy another small acreage in drainageways that dissect the association. Areas of Clarinda soils occur within larger areas of Lagonda soils.

This association contains mostly general farms about 240 acres in size. The less sloping areas are cultivated, and the steeper areas are kept in permanent pasture. Beef cattle and other kinds of livestock are raised on many of the farms. Row crops are grown extensively, and also other crops commonly grown in the county. Erosion is the chief hazard to farming these soils.

2. Shelby-Lagonda-Grundy Association

Moderately sloping to hilly, moderately well drained or somewhat poorly drained soils that have developed in glacial till on side slopes, and somewhat poorly drained soils that have developed in loess on ridgetops

This soil association is similar to association 1, except that the soils that formed in loess on the ridgetops are mainly of the Grundy instead of the Sharpsburg series. The association makes up about 20 percent of the county and occupies most of the interstream divides in the eastern third. The native vegetation was prairie grasses.

Shelby soils make up the largest part of the association. They are steeper than the other soils and are loamy and moderately well drained. These soils have developed in glacial till. They have a subsoil of yellowish-brown clay loam.

The Lagonda soils are somewhat poorly drained. They occur near the heads of drainageways and on nearby side slopes, below ridgetops occupied by Grundy soils. The Lagonda soils have developed mainly in erosional sediment and glacial till, and to a lesser extent in shallow loess. Their surface layer is generally silty. Their subsoil contains some gravel and coarse sand, and the lower part is grayish-brown silty clay. These soils have slopes of 5 to 11 percent. They are subject to severe erosion, especially if they are cultivated and are not protected. They are seepy and wet during rainy seasons.

The Grundy soils are gently sloping and, like the Lagonda, are somewhat poorly drained. They have developed in a layer of loess, 4 to 10 feet thick, on ridgetops, divides, and benches. The surface layer of these soils is dark-colored silt loam, and their subsoil is dark grayish-brown silty clay.

Minor soils are those of the Adair, Olmitz, Kennebec, and Clarinda series. The Adair soils are moderately well drained. They occur throughout the association, below areas of Grundy soils but above areas of Shelby soils. The Olmitz and Kennebec soils are moderately well drained or well drained, and the Clarinda soils are poorly drained. The Olmitz and Kennebec soils occur along the drainageways that dissect this association. The Clarinda soils occur within larger areas of Lagonda soils.

General farming is practiced throughout this association. The dissected areas are commonly used for permanent pasture, and the gently sloping areas are cultivated. Erosion has been severe in many places where the sloping soils have been cultivated.

3. Gara-Keswick-Pershing Association

Moderately sloping to steep, moderately well drained soils that have developed in glacial till on side slopes and ridges, and somewhat poorly drained soils that have developed in loess on bench terraces and ridgetops

This soil association consists mainly of steep Gara soils and of other soils on narrow bench terraces and ridgetops near rivers and creeks (fig. 3). Originally, it had a cover of trees that in some areas were scattered and in others grew in a dense stand. Erosion has been severe in most of the cultivated fields. The association occupies about 9 percent of the county.

The Gara soils, moderately well drained soils that have slopes of 9 to 35 percent, occupy more than half of this association. They have a loamy surface layer and a subsoil of yellowish-brown clay loam. These soils have developed in glacial till. In most places they are covered with trees and grasses and are used for pasture.

The Keswick soils are moderately well drained and are moderately sloping. They have developed in glacial till. Some areas of Keswick soils are on ridgetops below the Ladoga soils of the divides and above the Gara soils of the lower slopes. Other areas are on side slopes above the flood plains.

The Pershing soils are somewhat poorly drained and are gently sloping to moderately sloping. They are on uplands and benches, mainly in the eastern half of the county. These soils are silty and have developed in loess.

A minor acreage of this association is made up of moderately well drained Ladoga and Olmitz soils and of limestone outcrops. The Ladoga soils, like the Pershing, are on benches and on rounded ridgetops in the uplands, and they have slopes of 2 to 9 percent. They are within or adjacent to areas that were originally timbered. The Olmitz soils are in drainageways and at the base of colluvial slopes. The limestone outcrops occur in an area less than 100 acres in size in parts of the association bordering the East Fork Grand River. From some of these outcrops, rock is quarried for use in the construction of roads.

Some of the soils of this association were the first to be cultivated by the early settlers. Now, the soils are used mainly for pasture and trees, though cultivated crops are grown on a small acreage of gently sloping soils of the uplands and on small patches of soils of the bottom lands. Severe erosion has occurred in most of the areas that have been cultivated. Livestock farming is an important enterprise in this association.

4. Wabash-Nodaway-Kennebec Association

Nearly level, poorly drained soils that have developed in clayey sediment, and moderately well drained or well drained soils that have developed in silty alluvium; mainly on flood plains

This soil association consists mainly of soils on flood plains (fig. 4), but it contains a small acreage of soils on benches. The association occupies about 22 percent of the county.

The Wabash soils occur on flood plains of all the major streams, and they are subject to occasional flooding. They have developed in fine-textured alluvium, mostly under grasses, and are dark colored and poorly drained. Their surface layer is silty clay loam to clay, and the lower part of their profile is silty clay or clay.

The Nodaway soils are moderately well drained or well drained and are moderately dark colored. They have developed in silty recently deposited alluvium, mainly under

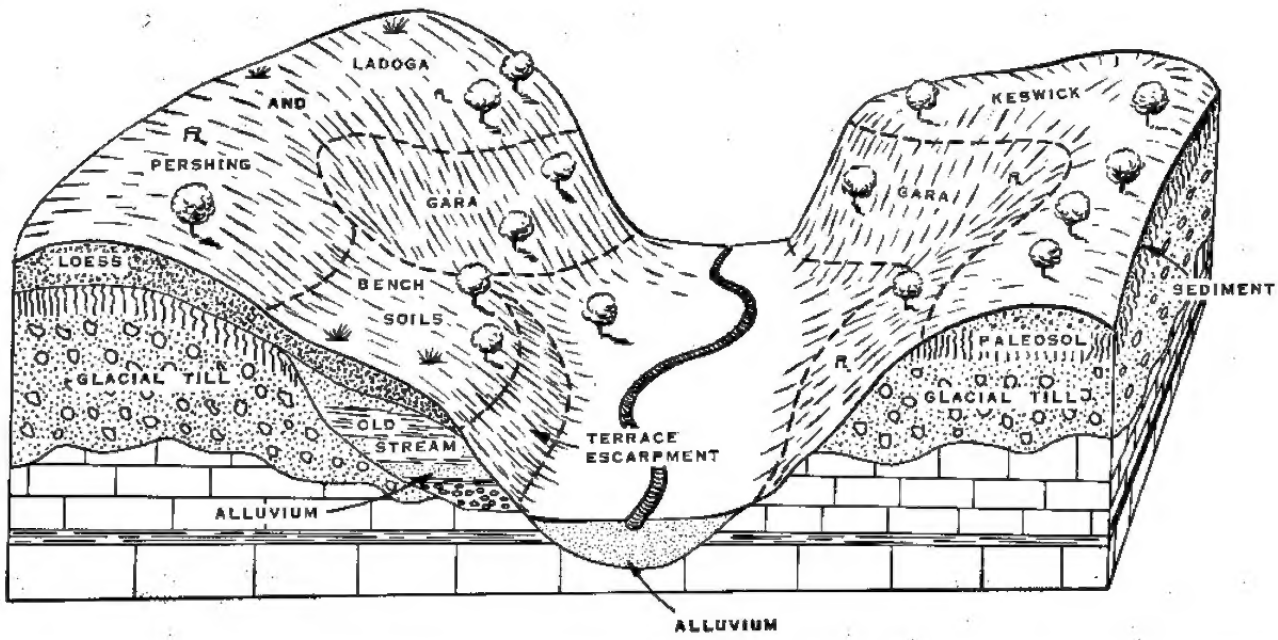

Figure 3.—**Typical landscape in association 3 showing relationship of major soils and the underlying material.**

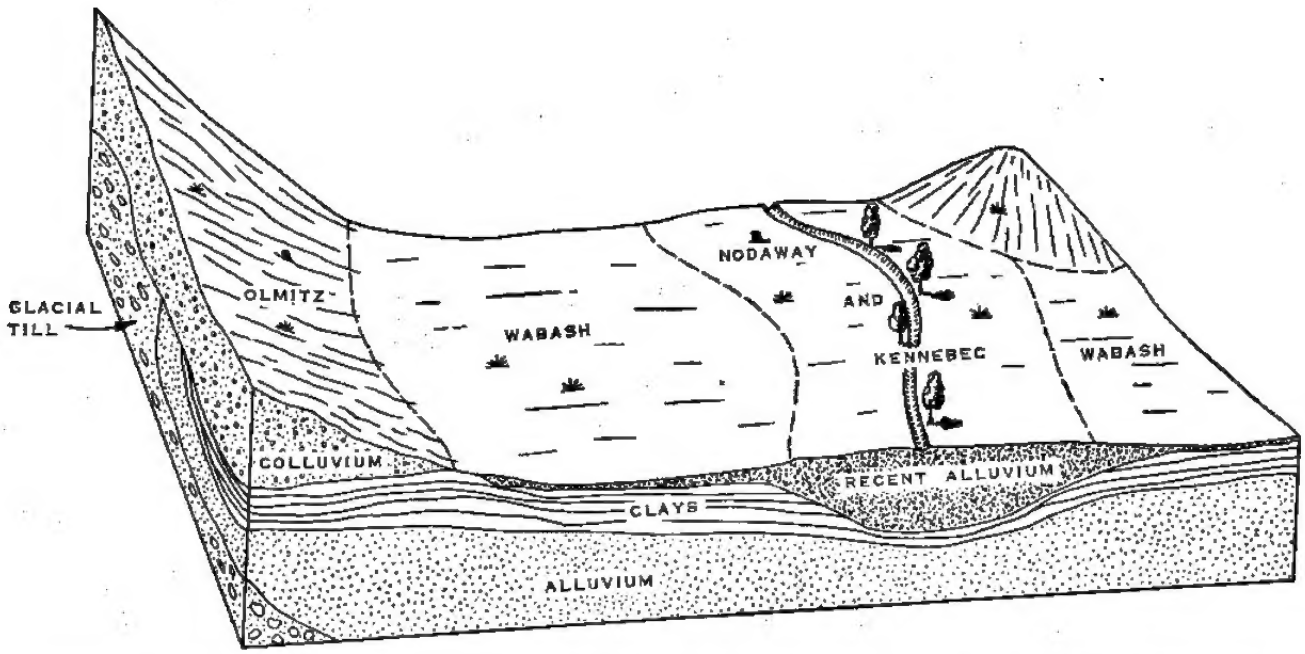

Figure 4.—**Typical landscape in association 4 showing relationship of major soils and the underlying materials.**

trees. These soils are close to the stream channel and are subject to frequent or occasional flooding.

The Kennebec soils generally lie between areas of Wabash and Nodaway soils. They are dark colored, are well drained or moderately well drained, and have a silty surface layer. Flooding is not a serious hazard, and these soils are suited to most crops grown in the area.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Worth County, where they are located, and how they can be used.

They went into the county knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. To use this survey efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Adair and Shelby, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that go with their behavior in the natural, untouched landscape. Soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Wabash silty clay and Wabash silty clay loam are two soil types in the Wabash series. The difference in texture of their surface layers is apparent from their names.

Some types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into phases. The name of a soil phase indicates a feature that affects management. For example, Sharpsburg silt loam, 2 to 5 percent slopes, is one of several phases of Sharpsburg silt loam, a soil type that is gently sloping or moderately sloping.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that greatly help in drawing boundaries accurately. The soil map in the back of this survey was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning management of farms and fields, a mapping unit is nearly

equivalent to a soil type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil type or soil phase.

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size that it is not practical to show them separately on the map. Therefore, they show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Olmitz-Kennebec complex, 0 to 5 percent slopes. Also, in some places two are more soils are mapped in a single unit, called an undifferentiated soil group or undifferentiated unit, if the differences between the soils are too small to justify separation, though these soils occur separately. An example of such a unit is Adair and Shelby loams, 5 to 9 percent slopes. Furthermore, on most soil maps, areas are shown where the soil material is so rocky, so shallow, or so frequently worked by wind and water that it cannot be classified by soil series. These areas are shown on the map like other mapping units but are given descriptive names, such as Terrace escarpments, and are called land types.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soils in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soils. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in a way that it is readily useful to different groups of readers, among them farmers, ranchers, managers of woodland, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in soil surveys. On the basis of yield and practice tables and other data, the soil scientists set up trial groups, and then test them by further study and by consultation with farmers, agronomists, engineers, and others. Then, the scientists adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

Descriptions of the Soils

This section describes the soil series and mapping units of Worth County. The acreage and proportionate extent of each mapping unit are given in table 1.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil name	Area	Extent
	Acres	*Percent*
Adair silt loam variant and Adair loam, 2 to 5 percent slopes, moderately eroded	1,362	0.8
Adair and Shelby loams, 5 to 9 percent slopes	5,239	3.1
Adair and Shelby loams, 5 to 9 percent slopes, moderately eroded	11,528	6.7
Adair and Shelby soils, 5 to 9 percent slopes, severely eroded	7,205	4.2
Alluvial land	943	.6
Edina silt loam, benches, 0 to 3 percent slopes	681	.4
Gara loam, 9 to 14 percent slopes, moderately eroded	1,310	.8
Gara loam, 14 to 20 percent slopes, moderately eroded	5,125	3.0
Gara loam, 20 to 35 percent slopes	2,728	1.6
Gara soils, 20 to 35 percent slopes, severely eroded	324	.2
Grundy silt loam, 2 to 5 percent slopes	4,192	2.5
Grundy silt loam, 2 to 5 percent slopes, moderately eroded	458	.3
Grundy silt loam, benches, 0 to 2 percent slopes	223	.1
Grundy silt loam, benches, 2 to 5 percent slopes	1,179	.7
Grundy silt loam, benches, 5 to 9 percent slopes, moderately eroded	406	.2
Kennebec silt loam	2,882	1.7
Keswick loam, 5 to 9 percent slopes	458	.3
Keswick loam, 5 to 9 percent slopes, moderately eroded	1,244	.7
Keswick loam, valleys, 5 to 9 percent slopes, moderately eroded	969	.6
Keswick loam, valleys, 9 to 14 percent slopes, moderately eroded	232	.1
Keswick soils, 5 to 9 percent slopes, severely eroded	393	.2
Keswick soils, valleys, 5 to 9 percent slopes, severely eroded	341	.2
Keswick soils, valleys, 9 to 14 percent slopes, severely eroded	187	0.1
Ladoga silt loam, 2 to 5 percent slopes	341	.2
Ladoga silt loam, 5 to 9 percent slopes, moderately eroded	654	.4
Ladoga silt loam, 9 to 14 percent slopes, moderately eroded	144	.1
Ladoga silt loam, benches, 2 to 5 percent slopes	223	.1
Ladoga silt loam, benches, 5 to 9 percent slopes, moderately eroded	183	.1
Lagonda and Clarinda soils, 5 to 11 percent slopes	2,751	1.6
Lagonda and Clarinda soils, 5 to 11 percent slopes, moderately eroded	8,253	4.8
Lagonda and Clarinda soils, 5 to 11 percent slopes, severely eroded	4,061	2.4
Nevin silt loam	196	.1
Nodaway silt loam	2,292	1.3
Nodaway silt loam, overflow	3,445	2.0
Olmitz loam, 2 to 5 percent slopes	5,973	3.5
Olmitz-Kennebec complex, 0 to 5 percent slopes	18,051	10.6
Pershing silt loam, 2 to 5 percent slopes	734	.4
Pershing silt loam, 2 to 5 percent slopes, moderately eroded	262	.2
Pershing silt loam, 5 to 9 percent slopes	275	.2
Pershing silt loam, 5 to 9 percent slopes, moderately eroded	432	.3
Pershing silt loam, benches, 2 to 5 percent slopes	1,035	.6
Pershing silt loam, benches, 2 to 5 percent slopes, moderately eroded	262	.2
Pershing silt loam, benches, 5 to 9 percent slopes, moderately eroded	498	.3
Pershing and Grundy soils, benches, 5 to 9 percent slopes, severely eroded	353	.2
Sharpsburg silt loam, 2 to 5 percent slopes	8,253	4.8

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

Soil name	Area	Extent
	Acres	*Percent*
Sharpsburg silt loam, 2 to 5 percent slopes, moderately eroded	720	0.4
Sharpsburg silt loam, 5 to 9 percent slopes	1,847	1.1
Sharpsburg silt loam, 5 to 9 percent slopes, moderately eroded	963	.6
Sharpsburg silt loam, benches, 3 to 8 percent slopes	1,002	.6
Sharpsburg soils, 5 to 9 percent slopes, severely eroded	203	.1
Shelby loam, 9 to 14 percent slopes	5,895	3.4
Shelby loam, 9 to 14 percent slopes, moderately eroded	11,796	6.9
Shelby loam, 14 to 20 percent slopes	4,585	2.7
Shelby loam, 14 to 20 percent slopes, moderately eroded	3,406	2.0
Shelby loam, 20 to 30 percent slopes	393	.2
Shelby and Gara soils, 9 to 20 percent slopes, severely eroded	17,946	10.5
Terrace escarpments	417	.2
Wabash silty clay	2,751	1.6
Wabash silty clay loam	10,676	6.2
Total	170,880	100.0

The procedure is first to describe the soil series, and then the mapping units in that series. Thus, to get full information on any one mapping unit, it is necessary to read the description of that unit and also the description of the soil series to which it belongs. As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Alluvial land and Terrace escarpments, for example, are miscellaneous land types that do not belong to a soil series. They are listed, nevertheless, in alphabetic order along with the soil series.

In comparing a mapping unit with a soil series, many will prefer to read the short description in paragraph form. It precedes the technical description that identifies layers by A, B, and C horizons and depth ranges. The technical profile descriptions are mainly for soil scientists and others who want detailed information about soils. Unless otherwise indicated, the colors given in the descriptions are those of a moist soil. Some of the terms used to describe the soils are defined in the Glossary at the back of the soil survey.

Following the name of each mapping unit, there is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit in which the mapping unit has been placed. The page on which each capability unit is described can be found by referring to the "Guide to Mapping Units" at the back of this survey.

Adair Series [2]

The Adair series consists of dark colored or moderately dark colored, moderately well drained, rolling soils on glacial till plains. These soils developed in erosional sediment and glacial till. They have a layer of small stones and pebbles in the upper part of the subsoil in many places. The original vegetation was forest, though more recently these soils have been covered by prairie vegetation.

The surface layer consists of dark-colored loam 10 to 18 inches thick. The upper part of the subsoil is dark-brown clay loam that grades to silty clay, and the lower part is olive-gray gritty clay.

Adair soils have high available moisture capacity and low to moderate natural fertility. They are medium acid to strongly acid. In their subsoil permeability is slow.

Representative profile of Adair loam (350 feet west of the SE. corner of the SW¼ of section 31, T. 66 N., R. 30 W.):

A1—0 to 9 inches, very dark gray (10YR 3/1) to very dark grayish-brown (10YR 3/2) loam; weak, fine, granular structure; friable; pH 5.8; clear boundary.

A3—9 to 14 inches, dark-brown (7.5YR 4/2 to 4/4) and very dark gray (10YR 3/1) to very dark grayish-brown (10YR 3/2) heavy loam that is very dark grayish brown (10YR 3/2) if crushed; moderate, fine, subangular blocky structure; friable; pH 5.2; gradual boundary.

B1—14 to 21 inches, dark-brown (7.5YR 4/3) light clay loam that is dark grayish brown (10YR 4/2) if crushed; moderate, fine, subangular blocky structure; friable; small root channels and worm casts; small, black concretions; pH 5.0; clear boundary.

IIB21t—21 to 28 inches, dark-brown (7.5YR 4/2) gritty silty clay; many, fine, dark-red (2.5YR 3/6) mottles and a few, medium, yellowish-brown (10YR 5/6) mottles; soil material dark brown (7.5YR 3/4) if crushed; strong, fine, angular blocky structure; very firm; thick, continuous clay films; pH 5.6; gradual boundary.

IIB22t—28 to 33 inches, olive-gray (5Y 5/2) gritty clay; many, medium, yellowish-red (5YR 4/8) mottles; soil material dark brown (7.5YR 4/4) if crushed; moderate, medium, subangular blocky structure; very firm; thick, continuous clay films; pH 5.6; gradual boundary.

IIB3t—33 to 40 inches, strong brown (7.5YR 5/8) gritty clay; few, medium, weak-red (2.5YR 5/2) mottles; soil material yellowish brown (10YR 5/4) if crushed; weak, medium, subangular blocky structure; very firm; continuous clay films; contains iron and manganese concretions; pH 6.0; gradual boundary.

IIC—40 to 60 inches, yellowish-brown (10YR 5/4) and reddish-brown (5YR 4/3) heavy clay loam; a few, coarse, gray (5Y 5/1) mottles; contains many iron and manganese concretions; massive; some clay films along cleavage faces; few, soft, red (10R 5/6) stones; pH 6.4.

The A horizons range from very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2) or very dark brown (10YR 2/2) in color and from loam or silt loam to light clay loam in texture. In most places the A horizons and the upper B horizon have developed in sediment of erosional origin. Adair soils have formed in less than 20 inches of sediment, though in this county the maximum thickness of this material is about 48 inches.

The upper B horizons range from reddish yellow (7.5YR 6/6) or strong brown (7.5YR 5/6) to dark yellowish brown (10YR 4/4) or dark brown (7.5YR 4/2 to 4/4). In most places the IIB22t horizon is olive gray (5Y 5/2). The combined thickness of the B horizons is variable and depends on the amount of soil material removed by geologic erosion. The texture of the B

[2] Derivation of the Adair soils is somewhat complex and is explained under the heading "Parent Material" in the section "Genesis, Morphology, and Classification of Soils."

horizons ranges from heavy clay loam to gritty silty clay or clay.

In some places the Adair soils are adjacent to Lagonda and Shelby soils. Where the Adair soils are on ridgetops, Shelby soils are on the lower side slopes. Where the Adair soils are on side slopes, Sharpsburg or Grundy soils are generally on the ridgetops. The Adair soils contain more sand and have more red mottles in the subsoil than the Lagonda soils. They have a finer textured subsoil than the Shelby soils but are more sandy and contain more stones than the Sharpsburg and Grundy soils.

Adair silt loam variant and Adair loam, 2 to 5 percent slopes, moderately eroded (AoB2).—This undifferentiated unit consists of Adair silt loam variant[3] and of Adair loam. These soils have developed in deep, silty sediment. In some places they occur together, but in others they occur separately.

Adair silt loam variant is dominant in this unit. It is on gentle, convex slopes on ridgetops, at a lower elevation than soils on the main divides but above steeper Adair and Shelby soils on the slopes below. The silty sediment in which this soil developed is 20 to 48 inches thick, or thicker than that in which the typical Adair soils formed.

Like the typical Adair soils, Adair silt loam variant is moderately well drained, but it is close to well drained in areas where the layer of sediment is thickest. The thick layer of sediment makes this variant more desirable for farming than Adair loam. The profile is similar to the one described for the Adair series, but firm, clayey glacial till is at a greater depth. Also, the surface layer is generally dark-colored gritty silt loam, though the texture ranges to loam in some places. The subsoil is generally a brown light silty clay loam.

Adair loam has the profile described for the Adair series. The part of its profile that developed in silty sediment is less than 20 inches thick over a very firm, clayey subsoil.

The soils of this unit are well suited to all the crops commonly grown in the county. Response to lime and fertilizer is good. Erosion is the major hazard. (Capability unit IIe-6)

Adair and Shelby loams, 5 to 9 percent slopes (AsC).—The soils of this unit are on ridgetops and side slopes. Adair loam occupies most of the ridgetops, and Adair loam and Shelby loam occur in about equal proportions on the side slopes. Included in areas mapped on the ridgetops were areas of a soil that is covered by a thick layer of silty overburden.

The soils of this unit have a dark colored surface layer that is generally more than 10 inches thick. In most places the upper part of the subsoil is dark-brown or yellowish-brown clay loam. The lower part of the subsoil in the Adair soil is dark-brown or yellowish-brown clay loam, and the lower part in the Shelby soils is mottled gray and brown clay loam.

These soils are moderately well suited to most crops grown in the area but are subject to erosion. The crops respond well to lime and fertilizer. (Capability unit IIIe-6)

[3] In some soil series, a variant is included. A variant has many of the characteristics of the series in which it is placed, but it differs in at least one important characteristic, which is indicated by its name. The acreage of a variant is of too small extent to justify establishing a new series. A new series may be designated and replace the variant, however, if sufficient acreage is later mapped.

Adair and Shelby loams, 5 to 9 percent slopes, moderately eroded (AsC2).—Soils of this unit are on low ridgetops and on side slopes. Erosion has removed part of the original surface layer, and the present surface layer is generally less than 7 inches thick. Included in the areas mapped were areas of Adair silt loam variant.

The soils of this unit are less fertile than they formerly were, but crops grown on them respond well to lime and fertilizer. Further erosion is a hazard, and these soils are generally low in available nitrogen and phosphorus. They are better suited to small grains, grasses, and legumes than to row crops. If terraces are installed to help control erosion, however, cultivated crops can be grown part of the time. (Capability unit IIIe-6)

Adair and Shelby soils, 5 to 9 percent slopes, severely eroded (AsC3).—The soils of this undifferentiated unit are on side slopes in the uplands. If they are cultivated, the plow layer extends into the subsoil. Further erosion is a hazard.

These soils are low in natural fertility and are difficult to work. They are subject to further severe erosion and are not well suited to row crops. The soils are suited to grasses and legumes grown for hay or pasture, and they can be used occasionally for a small grain. Response is good to applications of lime and fertilizer. (Capability unit IVe-6)

Alluvial Land

Alluvial land (0 to 4 percent slopes) (Au) is a light-colored to moderately dark colored miscellaneous land type that is nearly level or gently sloping and is somewhat poorly drained or poorly drained. It occurs with Nodaway soils on flood plains and low second bottoms and is adjacent to Wabash soils in many places.

The soil material near the surface is loam to silty clay loam to a depth of 12 to 30 inches and is stratified in places. In some areas slight development of horizons is apparent. The underlying material is dark-gray to black silty clay loam to clay.

The underlying material is slowly permeable. As a result, this land type remains wet after periods of heavy rainfall. The soil material near the surface is generally slightly acid, but the underlying material is strongly acid. The content of organic matter is low to medium. This land type tends to be droughty during the dry summer months. It is flooded occasionally, however, and is generally wet in spring. In places artificial drainage is necessary for satisfactory cropping. Diversion terraces effectively remove excess water in some areas.

This land type can be cropped intensively and is suited to corn, soybeans, and small grains. Wetness and poor aeration make it unsuitable for legumes. The crops respond well to applications of nitrogen fertilizer. If all crop residue is plowed under, and if an adequate amount of fertilizer is applied and minimum tillage is practiced, the land remains suitable for crops, even though row crops are grown year after year. (Capability unit IIIw-1)

Clarinda Series

The Clarinda series consists of soils that are dark colored and poorly drained. These soils are generally just below the tops of the highest ridges. The material in which

they developed is primarily gray, clayey glacial till that was within 20 inches of the surface after geologic erosion removed most of the loess and erosional sediment from the slopes. The slopes range from 5 to 11 percent.

The surface layer is heavy silt loam to heavy silty clay loam. The subsoil is silty clay and clay.

These soils are very slowly permeable and are seepy and wet after periods of excessive rainfall. They tend to be droughty during dry periods. The upper layers are medium acid to strongly acid, and the lower layers are slightly acid to neutral. Natural fertility is low. Erosion is already moderate to severe in many places, and these soils are highly susceptible to further erosion.

Representative profile of a moderately eroded Clarinda soil that has slopes of 7 percent (NW¼NE¼NE¼NW¼ of section 3, T. 67 N., R. 33 W.):

Ap—0 to 6 inches, very dark gray (10YR 3/1) heavy silt loam to light silty clay loam; fine granular structure; friable; few, fine, quartz sand grains; pH 6.2; roots plentiful; abrupt boundary.

A3—6 to 9 inches, very dark grayish-brown (10YR 3/2) heavy silt loam to light silty clay loam; fine granular and very fine subangular blocky structure; friable; roots plentiful; pH 6.0; clear boundary.

B1—9 to 15 inches, very dark gray (10YR 3/1) silty clay; faint, dark grayish-brown (10YR 4/2) mottles and a few, fine, distinct, brown (7.5YR 5/4) mottles; weak to moderate, very fine, subangular blocky structure; firm; numerous, fine, gritty particles visible; plentiful roots; pH 5.8; clear boundary.

B21g—15 to 21 inches, dark-gray (5YR 4/1) clay; about 10 percent contains dark grayish-brown (10YR 4/2) and brown (10YR 5/3) mottles; weak, medium, subangular blocky structure; firm; contains particles of fine and medium sand and grit; a few roots; pH 5.8; clear boundary.

B22g—21 to 28 inches, gray (5Y 5/1) clay; common, fine, yellowish-brown (10YR 5/6) mottles; weak, medium to coarse, subangular blocky structure; firm; prominent clay films on the surfaces of peds and in pores; particles of sand and gritty material common; pH 6.0; gradual boundary.

B3g—28 to 38 inches, gray (10YR 5/1) clay; coarse, yellowish-brown (10YR 5/6) and light olive-brown (2.5Y 5/4) mottles; weak, coarse, subangular blocky structure to massive; patchy clay films; particles of sand and grit common; many, soft, black concretions; pH 6.0; diffuse boundary.

C—38 to 48 inches +, gray (10YR 6/1) clay; many, coarse, yellowish-brown (10YR 5/6), light olive-brown (2.5Y 5/4) and dark-brown (7.5YR 4/4) mottles and streaks; firm; massive; numerous particles of sand and gritty material; pH 6.5.

The texture of the A horizons ranges from heavy silt loam to light silty clay loam. Depth to silty clay or clay is generally between 8 and 12 inches. Erosion has exposed the subsoil in some places. The color of the Ap horizon is extremely variable as a result; it ranges from black or very dark gray to gray within short distances.

Below a depth of about 12 to 20 inches, the characteristics of the soil material are inherited from an old, highly developed soil that was buried but has since been exposed. The color ranges downward from dark gray (10YR to 5Y 4/1) to light gray (5Y 6/1), and the texture is clay or very heavy silty clay. In places the light-gray color extends downward for several feet. Reaction is variable. These soils are normally medium acid to strongly acid in the upper part of the profile but are slightly acid to neutral at a depth of 40 to 48 inches.

In this county the Clarinda soils are intermingled with Lagonda soils and are mapped in undifferentiated units with those soils. The mapping units in which they occur are described under the Lagonda series.

Edina Series

The Edina series consists of moderately dark colored, poorly drained soils on bench terraces adjacent to the major streams. These soils are nearly level or very gently sloping, but they lie above areas of Terrace escarpments that are strongly sloping to steep. They have formed in loess under prairie grasses. The loess is normally 7 to 9 feet thick, but it is thinner in places on the lower terraces. Beneath the loess is alluvium.

The surface layer is dark colored and is 6 to 10 inches thick. It is underlain by a dark-gray or gray subsurface layer 6 to 12 inches thick. The upper part of the subsoil is very dark gray silty clay, and the lower part is dark-gray to grayish-brown silty clay to silty clay loam. The substratum is grayish-brown silty clay loam.

Permeability is very slow, and the available moisture capacity is high. Natural fertility is moderately high, and the content of organic matter is medium. The surface layer is medium acid to slightly acid, and the subsoil is strongly acid.

Representative profile of Edina silt loam (near the NE. corner of the SW¼NW¼ of section 30, T. 65 N., R. 31 W.):

Ap—0 to 5 inches, very dark grayish-brown (10YR 3/2) silt loam, gray (10YR 5/1) when dry; moderate, fine, granular structure; friable; very fine pore spaces; contains partly decomposed vegetation that was plowed under the previous year; pH 6.0; clear boundary.

A1—5 to 9 inches, very dark grayish-brown (10YR 3/2) and some dark grayish-brown (10YR 4/2) silt loam, gray (10YR 5/1) when dry; moderate, fine, granular structure; friable; pH 5.6; abrupt boundary.

A21—9 to 14 inches, dark-gray (10YR 4/1) and some gray (10YR 5/1) silt loam, light gray (10YR 7/1) when dry; few, fine, dark yellowish-brown (10YR 4/4) mottles; moderate to strong, fine, subangular blocky structure; friable; pH 5.6; gradual boundary.

A22—14 to 18 inches, mixed dark-gray (10YR 4/1) and gray (10YR 5/1) heavy silt loam, light gray (10YR 6/1) when dry; many dark yellowish brown (10YR 4/4) mottles; moderate to strong, medium, subangular blocky structure; friable to slightly firm; pH 5.4; clear boundary.

B21t—18 to 24 inches, very dark gray (10YR 3/1) medium silty clay; some dark-gray (10YR 4/1) mottles and many fine mottles of yellowish brown (10YR 5/8); moderate, fine, subangular blocky structure; very firm; pH 5.0; gradual boundary.

B22t—24 to 32 inches, dark-gray (10YR 4/1) and yellowish-brown (10YR 5/8) light silty clay; moderate, medium, subangular blocky structure breaking to moderate to strong, very fine, subangular blocky structure; some very dark gray (10YR 3/1) clay films on the surfaces of the peds; very firm; many fine iron concretions; pH 5.2; gradual boundary.

B3—32 to 44 inches, grayish-brown (2.5Y 5/2) medium silty clay loam; many medium and fine mottles of yellowish brown (10YR 5/8) and some greenish-gray (5GY 5/1) streaks; moderate, fine, subangular blocky structure; firm; many iron concretions; pH 5.8; gradual boundary.

C—44 to 48 inches +, grayish-brown (2.5Y 5/2) light silty clay loam; many coarse mottles of dark yellowish brown (10YR 4/4); weak, medium, subangular blocky structure to massive; friable to firm; dark concretions abundant; pH 6.4.

The Ap and A1 horizons range from very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2) in color and from 6 to 10 inches in combined thickness. The A2 horizons range from dark gray (10YR 4/1) to grayish brown (2.5Y 5/2) in color and from 6 to 12 inches in combined thickness.

The B horizons have a texture of medium silty clay or light silty clay to medium silty clay loam and an estimated content of clay of 46 to 54 percent. The color of the B horizons ranges from very dark gray (10YR 3/1) or dark gray (10YR 4/1) in the upper horizons to grayish brown (2.5Y 5/2) in the lower horizons.

The C horizon has a texture of silty clay loam and ranges from gray (N 5/0) to grayish brown (2.5Y 5/2) in color.

The areas in which the Edina soils occur are similar to those occupied by the Grundy and Pershing soils. The Edina soils have A2 horizons that are lacking in the Grundy soils, however, and they have a thicker A1 horizon and grayer B horizons than the Pershing soils.

Edina silt loam, benches, 0 to 3 percent slopes (EbA).—This is the only Edina soil mapped in this county. It is nearly level or very gently sloping and is on bench terraces.

This soil is used mainly for row crops, but some areas are in hay or pasture. Wetness is the main hazard to farming, but sheet erosion is a hazard in some areas. Surface ditches can be used to provide drainage in depressions but are generally not needed. Tile drains do not work satisfactorily, because of the clayey subsoil.

In wet years alfalfa is difficult to establish on this soil, and established stands are subject to frost heaving in winter. Where row crops are grown most of the time, crop residue should be plowed under and minimum tillage practiced to help to maintain favorable soil structure. The crops respond to applications of fertilizer. Erosion-control practices are needed in the areas subject to sheet erosion. (Capability unit IIw–1)

Gara Series

The Gara series consists of moderately dark colored, moderately well drained soils that formed in glacial till. The original vegetation was prairie grasses, but more recently the vegetation has been trees. These soils have slopes of 9 to 35 percent. They occur in rolling to hilly areas, below areas of Pershing, Ladoga, and Keswick soils.

The surface layer is 5 to 10 inches thick and consists of very dark grayish-brown loam that grades to dark grayish brown. The upper part of the subsoil is dark yellowish-brown light clay loam, and the lower part is dark-brown or yellowish-brown clay loam mottled with gray.

Permeability is moderate to moderately slow in the subsoil, and the available moisture capacity and natural fertility are moderate. The surface layer is slightly acid to neutral, and the subsoil is slightly acid to strongly acid. The content of organic matter is medium. These soils are subject to severe erosion.

These soils are generally too steep for terracing and need to be protected by a permanent cover of grass or trees. Some areas are cultivated, but a large acreage is in pasture. Nearly half of the acreage is in trees.

Representative profile of a Gara loam that has slopes of 15 percent (600 feet south of the bridge across Little Rock Creek on Highway C, NE¼ of section 29, T. 65 N., R. 30 W.):

A1—0 to 6 inches, very dark grayish-brown (10YR 3/2) loam, gray (10YR 5/1) when dry; moderate, fine, granular structure; very friable; pH 6.8; clear boundary.

A3—6 to 12 inches, dark grayish brown (10YR 4/2) loam, light brownish gray (10YR 6/2) when dry; some mixing with the material from the A1 horizon has taken place; weak, very fine, granular structure and some weak, thin, platy structure; friable; pH 5.0; gradual boundary.

B1—12 to 21 inches, dark yellowish-brown (10YR 4/4) light clay loam, but dark brown (10YR 3/3) or a lighter brown (10YR 5/3) in some places; moderate to strong, fine, subangular blocky structure; firm; pH 5.4; gradual boundary.

B2—21 to 26 inches, dark-brown (10YR 4/3) heavy clay loam; coatings and stains of dark gray (10YR 4/1) on the peds, and a few, fine to medium, red (10YR 4/6) mottles; moderate, fine, subangular blocky structure; firm; pH 4.8; clear boundary.

B3—26 to 42 inches, yellowish-brown (10YR 5/6) medium clay loam; common, medium mottles of grayish brown (10YR 5/2); weak, medium, subangular blocky structure; firm; pH 4.8; diffuse boundary.

C—42 to 50 inches +, light brownish-gray (2.5Y 6/2) and brown (10YR 5/3) medium to light clay loam; weak, fine, subangular blocky structure to massive; firm; pH 6.4; diffuse boundary. Calcium carbonate is at a depth of 68 inches.

The A1 horizon ranges from 6 to 10 inches in thickness. When moist, it is very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2), and when dry, it is gray (10YR 5/1 to 6/1) or light brownish gray (10YR 6/2) to grayish brown (10YR 5/2). In steep areas the A1 horizon is thinner than in less sloping areas and the profile contains no A3 horizon. In other places the A3 horizon generally consists of dark grayish brown (10YR 4/2) loam.

The B horizons range from brown or dark brown (10YR 4/3) to yellowish brown (10YR 5/6) in color and from clay loam to clay in texture. Red mottling normally occurs in the B2 horizon in areas where these soils occur near Keswick or Adair soils. In most places carbonates are at some depth between 40 and 70 inches. The clay loam texture extends downward to unweathered till.

Gara loam, 9 to 14 percent slopes, moderately eroded (GaD2).—In about 75 percent of the acreage of this soil, erosion has removed part of the original surface layer and the present surface layer is less than 7 inches thick. In the remaining 25 percent, erosion has been only slight. Material from the horizon beneath the surface layer is mixed in the plow layer, and the subsoil is exposed in places.

This soil lies below areas of Ladoga, Pershing, and Keswick soils and above areas of Olmitz soils. Included with it in mapping were small areas of Keswick soils.

This Gara soil is generally not well suited to frequent cultivation, though some areas are suitable for cropping. Most of the areas have been cultivated and are eroded, and much of the acreage is now used for cultivated crops. This soil is suited to alfalfa and can be used for pasture or hay. (Capability unit IVe–6)

Gara loam, 14 to 20 percent slopes, moderately eroded (GaE2).—This soil lies below areas of Ladoga, Pershing, and Keswick soils. Small outcrops of limestone occur in the areas in the eastern part of the county.

In some places this soil is eroded as a result of cultivation. In others trees have provided protection from erosion, but the surface layer has apparently never been more than 4 to 6 inches thick. Material from the horizon beneath the surface layer has been mixed in the plow layer in plowed fields. The subsoil is yellowish-brown clay loam that is mottled with gray in the lower part, and it is generally strongly acid. On the lower slopes, carbonates are within 50 to 60 inches of the surface.

This soil is subject to further erosion. It should remain in permanent vegetation, except when a pasture or hayfield is renovated. Then, tillage ought to be on the contour. (Capability unit VIe–6)

Gara loam, 20 to 35 percent slopes (GaF).—This soil has a surface layer that is only 4 to 6 inches thick. The A3

horizon is absent in most places, but this soil contains a thin A3 horizon in places. The subsoil is friable and is near the surface. Calcareous material is within 48 inches of the surface in many places. In very steep areas near the East Fork Grand River, a few acres of rock outcrop were included in mapped areas of this soil.

Most of the acreage is in timber and should remain in timber. The open areas are suitable for pasture and are in bluegrass. (Capability unit VIIe–6)

Gara soils, 20 to 35 percent slopes, severely eroded (GrF3).—These soils are in small isolated spots where the timber has been cleared. The areas have been used for grazing without adequately protecting the soils, and severe erosion has resulted. The subsoil is exposed throughout much of the acreage, and some areas are gullied. Loss of the surface soil has resulted in loss of fertility. The exposed subsoil is normally hard when dry.

Only scanty vegetation covers these soils. The eroded areas should be protected from further erosion by establishing permanent vegetation. The soils are suitable both for grass and trees. (Capability unit VIIe–6)

Grundy Series

Dark-colored, somewhat poorly drained soils that have developed in loess make up the Grundy series. Gently sloping areas of these soils are on ridgetops in the uplands, and nearly level to moderately sloping areas are on benches. The Grundy soils on uplands are underlain by glacial till at a depth of 3 to 7 feet. Those on benches are underlain by old alluvium at a depth of 6 to 10 feet. The native vegetation was prairie grasses.

The upper part of the surface layer is very dark gray and very dark grayish-brown silt loam 10 to 20 inches thick, but the soil material in the lower part grades to silty clay loam. The subsoil generally consists of about 30 inches of dark grayish-brown silty clay loam to silty clay.

Permeability is slow, and the available moisture capacity is high to very high. Natural fertility and the content of organic matter are high. The upper layers of the profile are medium acid to slightly acid or neutral. In most places erosion has been only slight and further erosion is generally not a serious hazard.

If these soils are well managed, they are well suited to corn and soybeans. Much of the acreage is cultivated.

Representative profile of a gently sloping Grundy silt loam (about 100 feet east of the SW. corner of the SE¼SW¼ of section 29, T. 66 N., R. 30 W.):

Ap—0 to 5 inches, very dark gray (10YR 3/1) and very dark grayish-brown (10YR 3/2) medium to heavy silt loam; weak, fine, granular structure; friable; pH 6.6; abrupt, smooth boundary.

A3—5 to 11 inches, very dark gray (10YR 3/1) heavy silt loam, very dark grayish brown (10YR 3/2) if crushed; moderate, medium, granular structure and some moderate, fine, subangular blocky structure; friable; pH 6.6; gradual boundary.

B1—11 to 15 inches, very dark gray (10YR 3/1) to very dark grayish-brown (10YR 3/2) heavy silty clay loam; common, fine mottles of yellowish brown (10YR 5/4); very fine, moderate, subangular blocky structure; friable to firm; pH 5.8; clear boundary.

B21t—15 to 21 inches, very dark grayish-brown (10YR 3/2) to dark grayish-brown (10YR 4/2) light silty clay; many, medium mottles of yellowish brown (10YR 5/4); fine, moderate, subangular blocky structure; some coatings of very dark gray (10YR 3/1) on the surfaces of the peds; firm; thick, continuous clay films; a few, small, black concretions; pH 5.4; gradual boundary.

B22t—21 to 30 inches, dark grayish-brown (10YR 4/2) and some grayish-brown (2.5Y 5/2) medium silty clay; common, medium, yellowish-brown (10YR 5/4) and dark yellowish brown (10YR 4/4) mottles; moderate, medium, subangular blocky structure; firm; thick, continuous clay films; common, fine, black concretions; pH 5.8; gradual boundary.

B3t—30 to 44 inches, grayish-brown (2.5Y 5/2) light silty clay; common, coarse mottles of dark yellowish brown (10YR 4/4) and a few, medium, dark-brown (7.5YR 4/4) mottles; very dark grayish-brown (10YR 3/2) stains along old root channels; weak, medium, subangular blocky structure; firm; thin clay films; many, small, black concretions; pH 6.2; gradual boundary.

C—44 to 56 inches +, grayish-brown (2.5Y 5/2) medium silty clay loam; common, coarse, dark yellowish-brown (10YR 4/4) mottles and some light brownish-gray (2.5Y 6/2) mottles; massive; friable; many, black concretions and stains that become more numerous with increasing depth; pH 6.6.

The color of the A1 or Ap horizon ranges from very dark gray (10YR 3/1) or very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2). When the soil is dry, the surfaces of the peds in the A3 horizon are coated in some places with dark-gray (10YR 4/1) or gray (10YR 5/1) silt.

The color of the B horizons ranges from very dark gray or very dark grayish brown (10YR 4/2) to grayish brown (10YR 5/2). The texture of the B horizons ranges from light silty clay loam to medium silty clay.

The color of the C horizon ranges from grayish brown (2.5Y 5/2) to light brownish gray (2.5Y 6/2). In most places the color of the mottles is dark yellowish brown (10YR 4/4) or dark brown (7.5YR 4/4), but the mottles are gray (10YR 4/1) or olive brown (2.5Y 4/4) in a few places. The texture of the C horizon ranges from medium to light silty clay loam.

Grundy silt loam, 2 to 5 percent slopes (GsB).—This soil is on major divides and ridgetops in the uplands near areas of Lagonda, Clarinda, Adair, and Shelby soils that have steeper slopes. It occurs in the same general positions as those occupied by Sharpsburg silt loam, 2 to 5 percent slopes, but it has a more grayish color than the Sharpsburg soil and has a finer textured subsoil. Included with this soil in mapping were a few acres of a nearly level soil.

This Grundy soil is used extensively for cultivated crops and is well suited to corn, soybeans, small grains, and legumes. Erosion is the major hazard to farming. (Capability unit IIe–6)

Grundy silt loam, 2 to 5 percent slopes, moderately eroded (GsB2).—This soil is on ridgetops and divides. In most places erosion has removed all but about 6 inches of the original surface layer. All of the original surface layer has been removed in small areas.

This soil is suited to all the crops commonly grown in the county. The crops respond to applications of fertilizer, but erosion is a hazard if crops are grown. Terraces should be installed if row crops are grown. (Capability unit IIIe–6)

Grundy silt loam, benches, 0 to 2 percent slopes (GuA).—This soil is on benches along the major streams in the county. The largest acreage is along the East Fork Grand River.

The profile of this soil resembles that of the Edina soils, but this soil lacks a light-colored subsurface layer and has less clay in the subsoil. In most places the surface layer is 12 to 18 inches thick. It is generally thicker and darker colored than that of the more sloping Grundy soils. The structural peds in the lower part of the surface layer are generally coated with gray material. In places this soil

appears to be more nearly poorly drained than somewhat poorly drained.

This soil is well suited to corn, soybeans, small grains, and legumes. Row crops can be grown year after year if all the crop residue is plowed under, an adequate amount of fertilizer is applied, and minimum tillage is practiced. (Capability unit IIw–1)

Grundy silt loam, benches, 2 to 5 percent slopes (GuB).—This is a gently sloping soil on benches. Its surface layer is generally 8 to 15 inches thick, but the plow layer extends into the subsoil in some areas that were included in mapping.

This soil is well suited to all the crops commonly grown in this county. It is used for row crops and, to some extent, for pasture. Erosion is a hazard where the slopes are long or where this soil receives runoff from the uplands. If row crops are grown extensively, diversion terraces or other terraces are generally needed to protect the soils. (Capability unit IIe–6)

Grundy silt loam, benches, 5 to 9 percent slopes, moderately eroded (GuC2).—In most places the surface layer of this soil is 3 to 7 inches thick. It is as much as 10 inches thick in some places, however, and erosion has removed all of it in others.

If practices are used that control erosion, this soil is suited to all the crops commonly grown in the county. It is subject to severe erosion if it is cultivated and is not protected. (Capability unit IIIe–6)

Kennebec Series

The Kennebec series consists of dark-colored, well drained or moderately well drained soils that have developed in silty alluvium. These soils are nearly level to undulating. They occur on flood plains with Nodaway and Wabash soils.

The profile of the Kennebec soils consists of about 36 inches of very dark colored silt loam. This material is underlain by dark-colored heavy silt loam or light silty clay loam that contains a few gray and dark-brown mottles. Except in some areas that are covered by recent overwash, these soils are generally not stratified above a depth of 40 inches. The middle and lower parts of the profile have weak structure.

These soils are naturally fertile and are slightly acid to neutral in reaction. They have a moderately permeable subsoil and high available moisture capacity.

These are among the most desirable soils for farming in the county. They are used mainly for row crops.

Representative profile of a Kennebec silt loam that has slopes of about 1 percent (200 feet south of Marlow Branch and 50 feet south of the railroad in section 13, T. 65 N., R. 31 W.):

A11—0 to 7 inches, very dark brown (10YR 2/2) silt loam, dark gray (10YR 4/1) when dry; moderate, medium, granular structure; friable; pH 6.8; gradual boundary.

A12—7 to 17 inches, very dark gray (10YR 3/1) to black (10YR 2/1) silt loam, very dark grayish brown (10YR 3/2) if crushed; moderate, fine to medium, granular structure; friable; pH 7.0; gradual boundary.

AC—17 to 36 inches, very dark gray (10YR 3/1) silt loam; moderate, fine, prismatic structure; friable; many worm casts; pH 6.8; diffuse boundary.

C—36 to 56 inches, very dark grayish-brown (10YR 3/2) to very dark gray (10YR 3/1) heavy silt loam; few, fine, dark-gray (10YR 4/1) and dark-brown (10YR 4/3) mottles; weak, medium, prismatic structure; slightly firm; pH 6.6; faint stratification.

The A horizons range from black (10YR 2/1) or very dark gray (10YR 3/1) to very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2) in color, and these colors extend to a depth of 40 inches or more. The texture throughout the profile ranges from silt loam to light silty clay loam. In a few places, a layer of recent overwash, less than 18 inches thick and lighter colored than the typical soil, is on the surface. In many places stratified, medium-textured alluvium is at some depth below 40 inches. Where these soils are near the Wabash soils, their profile is clayey in places at a depth of 40 inches or more. Reaction is slightly acid to neutral to a depth of 40 inches.

Kennebec silt loam (0 to 2 percent slopes) (Kc).—This soil is mainly on flood plains of the larger streams. It also occurs, to some extent, on flood plains of the smaller streams and, in many places, lies between areas of Nodaway and Wabash soils. It is between areas of Wabash soils and the channel of the stream in other places.

Included with this soil in mapping were areas of wet, fine-textured soils that occupy the old stream channel where a stream channel has been improved. Also included were areas of dark-colored soils that are moderately fine textured to a depth of 4 to 5 feet.

Kennebec silt loam is well suited to all the crops commonly grown in the county. Row crops can be grown frequently, and there are no major hazards. Occasional flooding is a minor hazard, though the floodwaters rarely damage crops. Row crops can be grown year after year if all the crop residue is plowed under, enough fertilizer is applied, and minimum tillage is practiced. (Capability unit I–1)

Keswick Series

The Keswick series consists of moderately dark colored, moderately well drained soils that have developed in a thin layer of sediment (generally less than 18 inches thick) over glacial till. These soils are moderately sloping and are on the uplands. They occupy point ridges and slopes below areas of Ladoga and Pershing soils and above steeper slopes occupied by Gara soils. The valleys phases occupy the long, lower slopes that extend down to the flood plains.

In many places the surface layer is very dark grayish-brown loam 2 to 6 inches thick, and it grades to a brown, loamy subsurface layer, also about 2 to 6 inches thick. The upper part of the subsoil is dark-brown or strong-brown, firm silty clay loam to silty clay. The lower part is dark-brown or strong-brown, very firm clay mottled with gray and red.

In the valleys phases, the entire profile has developed in reworked material. The soil material has the same color and texture as that in the profile of normal Keswick soils. It generally contains more stones and pebbles than that in the normal Keswick soils, and it lacks the very firm consistence.

Permeability is moderately slow to slow, the available moisture capacity is high, and natural fertility is low. Erosion is a serious hazard. Reaction is slightly acid to very strongly acid in the surface layer, generally strongly acid to very strongly acid in the subsoil, and neutral below a depth of about 4 feet. Response to fertilizer is good.

Representative profile of a Keswick loam that has slopes of 6 percent (about 500 feet east of the SW. corner of the NE¼NE¼ of section 21, T. 66 N., R. 32 W.):

A1—0 to 4 inches, very dark grayish-brown (10YR 3/2) loam, light brownish gray (10YR 6/2) when dry; moderate, fine, granular structure; friable; pH 6.4; abrupt, irregular boundary.

A2—4 to 9 inches, brown (10YR 5/3), mixed with some dark grayish-brown (10YR 4/2), loam; weak, thin, platy structure and some weak, very fine, subangular blocky structure; friable; contains mole holes and a few worm casts; pH 4.6; clear boundary.

B1t—9 to 13 inches, dark-brown (7.5YR 4/4) heavy gritty silty clay loam or clay loam, reddish brown (5YR 4/3) when dry; brown (10YR 4/3) if crushed; very fine and fine, subangular blocky structure; firm; thin, continuous clay films; contains many pebbles, stones, and grains of coarse sand; roots common; pH 4.6; clear boundary.

IIB21t—13 to 17 inches, dark-brown (7.5YR 4/4) light clay, reddish brown (5YR 4/3) when dry; brown (10YR 4/3) if crushed; few, fine, grayish brown (10YR 5/2) and yellowish-red (5YR 4/6) mottles; strong, fine, subangular blocky and angular blocky structure; very firm; thick, continuous clay films; contains some coarse sand grains and a few small stones; some roots; pH 4.6; gradual boundary.

IIB22t—17 to 24 inches, dark yellowish-brown (10YR 4/4) light clay, reddish brown (5YR 4/3) when dry; brown (10YR 4/3 to 5/2) if crushed; few, medium, dark grayish-brown (10YR 4/2) mottles; strong, medium, subangular blocky structure; firm to very firm; thick, continuous clay films; contains some grains of coarse sand; pH 4.8; gradual boundary.

IIB23t—24 to 32 inches, strong-brown (7.5YR 5/6) heavy clay loam; brown (10YR 5/3) if crushed; a few, fine, grayish brown (10YR 5/2) mottles; moderate, medium, subangular blocky structure; firm; thin, continuous clay films; few, small, soft, weak-red (10YR 5/4) rocks; black stains along old root channels; few small iron and manganese concretions; pH 5.0; gradual boundary.

IIB3t—32 to 48 inches, yellowish-brown (10YR 5/6) medium clay loam; grayish brown (10YR 5/2) if crushed; many, coarse, light brownish-gray (10YR 6/2) mottles; a few dark yellowish-brown (10YR 4/4) oxide stains; weak, medium, subangular blocky structure; very firm; thin clay films; few iron and manganese concretions; pH 5.6; gradual boundary.

IIC—48 to 56 inches, yellowish-brown (10YR 5/6) light clay loam; many, coarse mottles of light brownish gray (10YR 6/2) and oxides of dark yellowish brown (10YR 4/4); massive; firm; thin clay films along cleavage faces; common iron and manganese concretions; pH 6.6; contains some free calcium carbonate.

The gritty sediment in which the A horizons originated ranges from silt loam to loam in texture. In timbered areas the A1 horizon ranges from 2 to 8 inches in thickness and has a color that varies slightly from very dark grayish brown (10YR 3/2). In some cultivated areas, the color of the Ap horizon ranges to dark grayish brown (10YR 4/2) or dark brown (10YR 4/3). In most places the A2 horizon is more loamy than the A1 and ranges from dark grayish brown (10YR 4/2) to grayish brown (10YR 5/2) or brown (10YR 5/3) in color.

The color of the B horizons ranges from dark brown (7.5YR 4/4) or yellowish brown (10YR 5/6) to reddish brown or yellowish red in a 5YR hue. In many places the B horizons have a more reddish color when dry than when moist. The texture of the B horizons ranges from heavy silty clay loam to clay. In many places a stone line occurs along the upper boundary of the IIB21t horizon. The B horizons range from medium acid to very strongly acid in reaction. In places the mottles in the IIB3t horizon have a chroma of 1 instead of 2.

The color of the IIC horizon is yellowish brown but ranges from 10YR 5/4 to 10YR 5/6 or 5/8. The texture in the upper part of the IIC horizon is medium clay loam in places, instead of light clay loam.

The profile in the valleys phases of Keswick soils resembles that of the Pershing soils. It has developed mainly in material of glacial origin, however, rather than in loess.

Keswick loam, 5 to 9 percent slopes (KeC).—This soil is on point ridges and side slopes, below soils formed in loess on ridgetops. It lies above areas of steeper Gara soils. The texture of the surface layer ranges to gritty silt loam in places. Included in mapping was a small acreage of a soil that formed in a layer of silty sediment as much as 40 inches thick.

In most places this Keswick soil is covered with trees and has never been cultivated, but some areas are used for crops or pasture. Erosion is the major hazard if this soil is farmed. Terraces are necessary to help to control erosion if cultivated crops are grown. This soil is generally low in available nitrogen and phosphorus. Favorable response is obtained if good management is used. (Capability unit IIIe-6)

Keswick loam, 5 to 9 percent slopes, moderately eroded (KeC2).—In most places this soil has a plow layer consisting of material from the original surface layer and the upper part of the subsoil. In much of the acreage, the plow layer extends into the subsoil. The texture of the surface layer is generally loam, but it is gritty silt loam in some places. The subsoil is dark brown and has reddish and grayish mottling below a depth of about 12 inches. Included in mapping were a few areas of a soil that has slopes of 3 to 4 percent.

This Keswick soil is used for cultivated crops or pasture. It is suited to most of the crops commonly grown in the county but has low natural fertility and is susceptible to further erosion. Installing terraces or keeping a cover of plants on the surface helps to control erosion. (Capability unit IIIe-6)

Keswick loam, valleys, 5 to 9 percent slopes, moderately eroded (KkC2).—This soil occurs mainly on the lower slopes of the uplands, above the flood plains. The surface layer is moderately dark colored, and typically, this soil contains a distinctly light-colored subsurface layer. In many places the surface layer and subsurface layers have been mixed by erosion and tillage. The subsoil is brown clay loam or gritty silty clay in most places and has grayish-brown, yellowish-red, or red mottles in the lower part.

This soil is used for pasture, hay, and row crops. It is low in natural fertility. Protection is needed from further erosion. (Capability unit IIIe-6)

Keswick loam, valleys, 9 to 14 percent slopes, moderately eroded (KkD2).—This soil is on the lower slopes of uplands that are adjacent to flood plains. The surface layer is thin and has a texture of clay loam in some places. In most places the subsoil is brown clay loam mottled with grayish brown in the lower part. Included with this soil in mapping are some gullied areas and other small areas in which the slopes are steeper than 14 percent. Scattered trees grow in small areas.

Unless this soil is protected, it is highly susceptible to further erosion. It is not suited to row crops, and fertilizer and lime are needed if a cover of grasses and legumes is to be established and maintained. It is suitable for permanent pasture and hay. If this soil is cultivated so that a pasture or meadow can be established, tillage should be on the contour to reduce the hazard of erosion. (Capability unit VIe-6)

Keswick soils, 5 to 9 percent slopes, severely eroded (KsC3).—These soils generally have a surface layer of light clay loam, but the texture is silt loam to heavy clay loam in some places. Mixing of material from the subsoil with that in the plow layer has given the plow layer a reddish color. The present surface layer is clayey and low in fertility. It is hard to till, and preparing a suitable seedbed is difficult. A subsoil of dark-brown, mottled clay lies just below the surface layer.

These soils are suitable for permanent pasture or hay. They are not suitable for row crops unless practices are used that control erosion. (Capability unit IVe-6)

Keswick soils, valleys, 5 to 9 percent slopes, severely eroded (KvC3).—These soils are eroded, and gullies occur in some places. The areas in which erosion has been especially severe are very low in fertility.

Areas of these soils that are not gullied can be cropped but are better suited to permanent pasture or hay than to cultivated crops. If cultivated crops are grown, practices that control erosion are needed. (Capability unit IVe-6)

Keswick soils, valleys, 9 to 14 percent slopes, severely eroded (KvD3).—Recent erosion has removed nearly all of the original surface layer of these soils. The gritty silty clay of the subsoil is exposed, and this material is normally hard and cloddy when dry. Natural fertility is very low. These soils are suitable for trees and are suitable for pasture if the areas are renovated and protected from further erosion. In most places the soils are free of desirable trees, but they support brush and timber of poor quality. The vegetation is normally weedy and grows in a sparse stand. (Capability unit VIe-6)

Ladoga Series

The Ladoga series consists of moderately dark colored, moderately well drained soils that have developed in loess. These soils are on ridgetops in the uplands and on benches throughout the county but are mainly in the western part. Generally, they are above areas of sloping Keswick and Gara soils. The soils range from gently sloping to strongly sloping, but the areas on uplands are gently sloping to moderately sloping. The native vegetation was grasses, but trees have invaded fairly recently.

The surface layer is dark-colored silt loam about 5 inches thick. It is underlain by a lighter colored subsurface layer about 5 to 6 inches thick. The subsoil is mainly brown silty clay loam. It has no gray colors in the uppermost 4 to 10 inches.

The surface layer puddles when wet and forms a crust when dry. The subsoil has moderately slow permeability. The available moisture capacity is high, and natural fertility is moderate. Reaction is slightly acid in the surface layer and strongly acid or very strongly acid in the subsoil.

Erosion is a severe hazard if cultivated crops are grown on these soils. Most of the areas are cultivated, however, though some remain in timber or in permanent pasture.

Representative profile of a Ladoga silt loam that has slopes of 4 percent (200 feet east of the Oxford Church in the SE¼NE¼ of section 19, T. 65 N., R. 32 W.):

A1—0 to 5 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) when dry; very dark grayish brown (10YR 3/2) if crushed; moderate, fine, granular structure; friable; many fine grass roots and large tree roots; pH 7.0; clear, wavy boundary.

A2—5 to 11 inches, dark grayish-brown (10YR 4/2) and some very dark grayish-brown (10YR 3/2) silt loam, light brownish gray (10YR 6/2) when dry; weak, fine, subangular blocky structure and some weak, very thin, platy structure; friable; pH 5.8; gradual boundary.

B1t—11 to 15 inches, brown (10YR 5/3) light silty clay loam, light brownish gray (10YR 6/2) when dry; weak, fine, subangular blocky structure; friable; thin, patchy clay films; pH 5.2; clear boundary.

B21t—15 to 18 inches, brown (10YR 4/3) medium to heavy silty clay loam; strong, fine, angular and subangular blocky structure; firm; when dry, surfaces of the peds coated with gray (10YR 6/1); pH 4.8; clear boundary.

B22t—18 to 26 inches, brown (10YR 4/3) heavy silty clay loam; occasional small, dark yellowish-brown (10YR 4/4) mottles; moderate to weak, fine, subangular blocky structure; very firm; thick clay films; pH 4.6; gradual boundary.

B23t—26 to 35 inches, brown (10YR 4/3) medium silty clay loam; many, medium, faint, grayish-brown (2.5Y 5/2) and dark yellowish-brown (10YR 4/4) mottles; weak, fine, subangular blocky structure; firm; clay films; contains tree roots; pH 4.8; gradual boundary.

B3—35 to 46 inches, grayish-brown (2.5Y 5/2) and dark yellowish-brown (10YR 4/4) medium silty clay loam; has some black stains and a few, small, dark concretions in the lower part; weak, very fine, subangular blocky structure; firm; pH 5.2; gradual boundary.

C—46 to 54 inches, grayish-brown (2.5Y 5/2) light silty clay loam; many, medium, dark yellowish-brown (10YR 4/4) mottles and many, small, black concretions and stains; weak, medium, subangular blocky structure; firm to friable; pH 5.0.

The A1 horizon ranges from very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2) or dark grayish brown (10YR 4/2) in color and from 4 to 6 inches in thickness. The A2 horizon ranges from dark grayish brown (10YR 4/2) to grayish brown (10YR 5/2) in color and from 2 to 6 inches in thickness.

The B horizons range from brown (10YR 5/3 to 4/3) to dark brown (7.5YR 4/4) or grayish brown (2.5Y 5/2) in color. In the uppermost 4 to 10 inches, the B horizons are free of grayish mottles, but the soil material below is mottled.

Ladoga silt loam, 2 to 5 percent slopes (LaB).—This gently sloping soil is on ridgetops in timbered areas of the uplands, mainly adjacent to the West Fork Grand River. In many places it is adjacent to Sharpsburg soils on the major divides and lies above areas of steeper Gara and Keswick soils. In most places it has slopes of about 4 percent. Included in mapping were areas of an eroded soil.

The Ladoga soil is suited to corn, soybeans, grasses, and legumes, but it is subject to erosion. The crops respond to applications of lime and fertilizer. If cultivated crops are grown, practices that control erosion are needed. (Capability unit IIe-6)

Ladoga silt loam, 5 to 9 percent slopes, moderately eroded (LaC2).—This soil is on rounded point ridges and on side slopes above areas of Gara and Keswick soils. It is already moderately eroded and is subject to severe erosion if it is not protected. The plow layer consists of soil material that has been mixed with the original surface soil by tillage.

Included with this soil in mapping were some areas that are not eroded and some severely eroded and gullied areas. The acreage of included soils is extensive.

This Ladoga soil can be cultivated. Practices that control erosion are needed, however, and the crops require large applications of lime and fertilizer. (Capability unit IIIe-6)

Ladoga silt loam, 9 to 14 percent slopes, moderately eroded (LaD2).—This soil is on side slopes, mostly below

less sloping Ladoga soils on the ridgetops. It has developed mainly in thin to thick deposits of loess or in material that resembles loess, but the lower part of its profile formed in glacial till in some places. Throughout most of the acreage, erosion has removed part of the surface layer.

This soil is suitable for pasture or hay, or it can be used for trees. The slopes and susceptibility to erosion make it poorly suited to cultivation. (Capability unit IVe-6)

Ladoga silt loam, benches, 2 to 5 percent slopes (LbB).—This soil occupies small areas along streams throughout the county. Mainly it occurs with Pershing soils on benches. Alluvium at a depth of 4 to 10 feet is the underlying material. Except that this soil is on benches and is underlain by alluvium, it is much like the Ladoga soils of the uplands. It generally has slopes of about 2 to 3 percent. Included in mapping were small spots occupied by an eroded soil.

This Ladoga soil is suitable for row crops. The crops respond to lime and fertilizer, especially to nitrogen and phosphorus. Erosion is the major hazard to farming, but tilling on the contour generally provides adequate protection from erosion. (Capability unit IIe-6)

Ladoga silt loam, benches, 5 to 9 percent slopes, moderately eroded (LbC2).—This soil occurs on benches, generally with Pershing soils. In most places the plow layer consists of part of the subsoil mixed with remnants of the original surface layer. Included in mapping were some areas of a soil that is not eroded, and other spots in which erosion has been severe. If this Ladoga soil is cultivated and is not protected, severe erosion is a hazard. (Capability unit IIIe-6)

Lagonda Series

The Lagonda series consists of dark-colored, somewhat poorly drained soils that have a silty surface layer. These soils occur with Clarinda soils around the heads of draws and on the adjacent side slopes of upland drainageways. They have developed under tall prairie grasses in highly weathered glacial till and erosional sediment.[4] Their slopes range from 5 to 11 percent.

In many places the surface layer is black to very dark gray and is 10 to 20 inches thick. The texture is silt loam in the upper part of the surface layer, but it grades to silty clay loam in the lower part. The upper part of the subsoil is very dark gray or dark grayish-brown heavy silty clay loam that contains brownish mottles. The lower part is dark grayish-brown silty clay that is underlain by gray clay or silty clay below a depth of about 36 inches.

Permeability is slow, available moisture capacity is high, and natural fertility is moderate. The reaction varies, but these soils become less acid with increasing depth. The subsoil is generally medium acid to strongly acid. Many of the areas are moderately or severely eroded.

Representative profile of a Lagonda silt loam that has slopes of 7 percent (SW¼SE¼SW¼NW¼ of section 23, T. 65 N., R. 31 W.):

A1—0 to 12 inches, black (10YR 2/1) silt loam; strong, very fine, granular structure; very friable; abundant roots; few, fine and medium, clear quartz sand grains; pH 6.8; clear boundary.

A3—12 to 16 inches, black (10YR 2/1) light silty clay loam, very dark brown (10YR 2/2) if crushed; moderate, fine, subangular blocky structure breaking to moderate, fine, granular structure; friable; abundant roots; common, fine and medium, clear sand grains; pH 6.0; clear boundary.

B1—16 to 20 inches, very dark gray (10YR 3/1) heavy silty clay loam; few dark grayish-brown (10YR 4/2) and brown (10YR 4/3) mottles; moderate to strong, fine, subangular blocky structure; friable; plentiful roots; numerous, fine to medium, clear quartz sand grains; common, gray (10YR 6/1), granular coatings on the surfaces of the peds when soil material is dry; pH 5.8; clear boundary.

B21t—20 to 24 inches, dark grayish-brown (10YR 4/2) light silty clay; common, brown (10YR 5/3) and yellowish-brown (10YR 5/6) mottles and a few, strong-brown (7.5YR 5/6) mottles; moderate, medium, subangular blocky structure breaking to fine subangular and angular blocky structure; firm; dark-gray (10YR 4/1) clay films on the surfaces of most structural peds; very dark gray (10YR 3/1) clay films in some vertical cracks; plentiful roots; common grains of sand; pH 6.4; clear boundary.

B22t—24 to 32 inches, mottled gray (10YR 5/1) and yellowish-brown (10YR 5/4) silty clay; thick, grayish brown (2.5Y 5/2) clay films coat the surfaces of the peds; 20 percent of soil material, by volume, has fine, yellowish-brown (10YR 5/6) mottles in the interiors of the peds; moderate, medium, subangular blocky structure; firm; contains plentiful roots, coarse sand, and occasional small pebbles; pH 6.6; gradual boundary.

B23tg—32 to 42 inches, silty clay; thick, gray (5Y 5/1) clay films coat the peds; occasional streaks or splotches of dark gray (5Y 4/1); light olive-brown (2.5Y 5/4), but tending toward yellowish-brown (10YR 5/4 and 5/6) ped interiors; weak, fine, subangular blocky structure; very firm; contains clear sand grains and an occasional pebble; plentiful roots; pH 6.6; gradual boundary.

B3g—42 to 46 inches, gray (5Y 5/1) silty clay; contains yellowish-brown (10YR 5/6) mottles or horizontal streaks; weak, fine, subangular blocky structure; sticky and plastic when wet; few roots; contains larger amounts of sand and gravel (some pebbles colored) than are in the A horizons and other B horizons; lower part of horizon consists of a thin pebble band, or stone line; clear boundary.

IICg—46 to 50 inches +, gray (5Y 5/1 to 5Y 6/1) gritty clay; a few, brownish-yellow (10YR 6/8) mottles; strong brown (7.5YR 5/6) at increasing depths; massive.

In areas that are not eroded, the color of the A1 or Ap horizon ranges from black (10YR 2/1) or very dark gray (10YR 3/1) to dark grayish brown (10YR 3/2) or, in a few places, to very dark brown (10YR 2/2). The texture of the A1 or Ap horizon is dominantly silt loam but ranges from loam to silty clay loam. Where these soils are eroded, the Ap horizon is extremely variable in color and texture.

The texture of the B horizons ranges from light silty clay loam to light clay, and the color of those horizons grades from a 10YR to a 5Y hue with increasing depth. The value ranges from 3, in the upper part of the profile, to 6, in the lower. The chroma is dominantly 1 and 2.

The mottles in the upper B horizons range from brown (10YR 4/3), strong brown (7.5YR 5/6), or yellowish brown (10YR 5/6) to yellowish red (5YR 5/8) or dark red (2.5YR 3/6). The red mottles do not occur in all areas, and the pebble band is absent in some places.

The C horizon and the lower part of the B horizon generally have a chroma of 1. In most places lime concretions occur below a depth of 5 to 6 feet.

The Logonda soils were not mapped separately in Worth County but were mapped with the Clarinda soils. A representative profile for the Clarinda soils is described under the Clarinda series.

Lagonda and Clarinda soils, 5 to 11 percent slopes (LcC).—The soils of this undifferentiated unit are mainly

[4] The derivation of the Lagonda soils is complex. It is discussed in more detail under the heading "Parent Material," in the section "Genesis, Morphology, and Classification of Soils."

around the heads of draws and on the adjacent side slopes. They lie below the ridgetops on uplands. Clarinda soils occupy about 20 percent of the total acreage, and Lagonda soils occupy most of the rest. The surface layer has a texture of silt loam to silty clay loam, is 7 to 12 inches thick, and is high in content of organic matter (fig. 5). Little or no erosion has taken place, though these soils are subject to erosion. Natural fertility is moderate.

These soils are suitable for row crops if they are protected from erosion. In most places terraces can be installed because the slopes are generally nearly uniform and are favorable for them. The soils are seepy and wet after periods of excessive rainfall. Therefore, frost heaving and winterkilling are common in winter. Alfalfa can be grown, but the stand usually lasts only a few years. (Capability unit IIIe–6)

Lagonda and Clarinda soils, 5 to 11 percent slopes, moderately eroded (LcC2).—In this unit about one-third of the total acreage consists of Clarinda soils, and the rest is Lagonda soils. Erosion has removed all but about 7 inches of the original surface layer, and most areas contain a few gullies. When the soils are plowed, soil material from the subsoil is mixed with the rest of the surface soil.

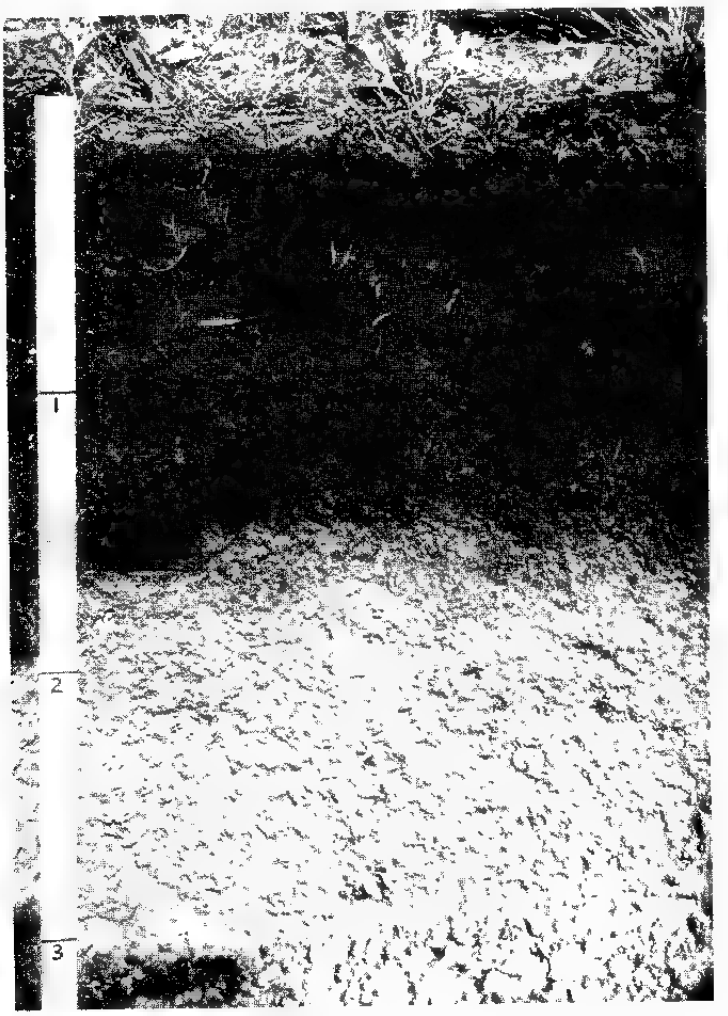

Figure 5.—**Profile of Lagonda silt loam showing the dark-colored surface layer high in content of organic matter.**

The present surface layer is heavy silt loam or silty clay loam, but it becomes more clayey if erosion is not controlled. The soils are highly susceptible to further erosion. Natural fertility is moderate to low.

These soils are suited to all the crops commonly grown in the county, but erosion has made them less fertile than they formerly were. Lime and fertilizer are needed, as well as practices that control erosion. The slopes are nearly uniform and are well suited to terraces. These soils contain seepy areas. In some winters legumes growing on them are damaged by frost heaving. (Capability unit IIIe–6)

Lagonda and Clarinda soils, 5 to 11 percent slopes, severely eroded (LcC3).—The soils of this unit are on concave slopes around the heads of upland drainageways. Clarinda soils make up about a third of the total acreage. In most places erosion has removed all of the original surface layer, and most areas contain gullies or places where old gullies have been filled. The present surface layer is dark-gray or dark grayish-brown silty clay loam or silty clay.

These soils are not well suited to row crops. Severe erosion makes them droughty, and natural fertility is low. The soils are seasonally wet, however, and are suited to grasses and legumes that tolerate water. The grasses and legumes respond to applications of fertilizer. (Capability unit IVe–6)

Nevin Series

The Nevin series consists of dark-colored, moderately well drained or somewhat poorly drained soils that are nearly level or undulating. These soils have formed in silty material. They are mainly on low terraces or benches, but some areas are on higher benches above the flood plains and others are on bottom lands. The Nevin soils on bottom lands grade to the surrounding soils formed in alluvium. The natural vegetation was grasses.

The surface layer is dark-colored silt loam 10 to 24 inches thick. The upper part of the subsoil is dark-colored silty clay loam, and the lower part is lighter colored (dark grayish brown or grayish brown) silty clay loam.

Permeability is moderate, but the flow of water through the lower part of the profile is sometimes restricted by a high water table during some parts of the year. Surface drainage is adequate for growing crops, and wetness is not a hazard if the soils are farmed. The available moisture capacity and natural fertility are high. Reaction is generally medium acid to slightly acid throughout the profile.

Representative profile of Nevin silt loam (200 feet north and 40 feet west of the southeastern corner of section 24, T. 65 N., R. 32 W.):

Ap—0 to 6 inches, black (10YR 2/1) to very dark brown (10YR 2/2) silt loam; weak, fine, granular structure; friable; pH 6.4; clear boundary.

A1—6 to 10 inches, black (10YR 2/1) silt loam; moderate, fine, granular structure; friable; pH 6.2; gradual boundary.

A3—10 to 13 inches, very dark gray (10YR 3/1) heavy silt loam; moderate, fine, granular and subangular blocky structure; friable; pH 6.2, clear boundary.

B1—13 to 18 inches, very dark gray (10YR 3/1) light silty clay loam; very dark brown (10YR 2/2) if crushed; common, medium, yellowish-brown (10YR 5/4) mottles; moderate, fine, subangular blocky structure; friable; pH 6.2; gradual boundary.

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B21t—18 to 23 inches, very dark grayish-brown (10YR 3/2) medium silty clay loam; dark grayish brown (10YR 4/2) if crushed; common, medium, yellowish-brown (10YR 5/4) mottles; moderate, fine, subangular blocky structure; friable to firm; thin clay films; pH 6.0; gradual boundary.

B22t—23 to 30 inches, dark grayish-brown (10YR 4/2) medium silty clay loam; common, fine, grayish-brown (2.5Y 5/2) and dark yellowish-brown (10YR 4/4) mottles; moderate, fine, subangular blocky structure; firm; thin clay films; pH 5.8; gradual boundary.

B23t—30 to 40 inches, grayish-brown (2.5Y 5/2) medium silty clay loam; surfaces of some peds dark grayish brown (2.5Y 4/2); common, medium, dark yellowish-brown (10YR 4/4) mottles; black stains on the surfaces of the peds; weak to moderate, medium, subangular blocky structure; firm to friable; thin, patchy clay films; pH 5.6; gradual boundary.

C—40 to 48 inches, grayish-brown (2.5Y 5/2) medium silty clay loam that contains some sand; many, coarse, dark yellowish-brown (10YR 4/4) mottles; massive; friable to firm; pH 6.0.

The A horizons have a texture of silt loam and range from black (10YR 2/1) to very dark brown (10YR 2/2) or very dark gray (10YR 3/1) in color. The combined thickness of the A horizons ranges from 10 to 24 inches.

The B horizons range from 10YR to 2.5Y in hue and have values of 3 to 5 and a chroma of 1 or 2. The texture of the B horizons is light to heavy silty clay loam.

The C horizon ranges from gray (N 5/0) to grayish brown (2.5Y 5/2) in color and from silty clay loam to clay loam in texture.

Nevin silt loam (0 to 2 percent slopes) (Ne).—This is the only Nevin soil mapped in Worth County. It is on stream terraces and low benches in undulating areas, mainly along the Platte River and the West Fork Grand River. All the areas are high enough above the flood plains that flooding does not occur, and surface drainage is good.

This soil is well suited to row crops. It can be used for row crops year after year if all crop residue is plowed under, an adequate amount of fertilizer is applied, and minimum tillage is practiced. (Capability unit IIw–1)

Nodaway Series

The Nodaway series consists of moderately dark colored, nearly level or undulating soils that are moderately well drained or well drained. These soils have developed in stratified, silty, recently deposited alluvium. They are on flood plains that border the channels of streams, mainly adjacent to Kennebec or Wabash soils. Frequent flooding is a hazard unless the stream channel has been improved. The native vegetation was mainly trees but included some grasses.

The surface layer is very dark grayish-brown to dark grayish-brown silt loam 6 to 12 inches thick. It is underlain by very dark grayish-brown, brown, pale-brown, and dark yellowish-brown, stratified, silty material.

Permeability is moderate, and the available moisture capacity and natural fertility are high. These soils are neutral to slightly acid.

Growing row crops is the main use of these soils. Some small, narrow areas that are frequently flooded, however, are not well suited to row crops.

Representative profile of a nearly level Nodaway silt loam (about 100 feet north of the bridge across Marlow Creek, on the west-facing streambank, in the SW¼SE¼ of section 30, T. 66 N., R. 31 W.):

A1—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam that is light brownish gray (10YR 6/2) when dry; contains a few layers of brown (10YR 5/3) very fine sandy loam less than 1 inch thick; weak, granular structure, but in places the soil material breaks to chunks ¾ to ½ inch in diameter; very friable; pH 7.0; diffuse boundary.

C1—7 to 30 inches, very dark grayish-brown (10YR 3/2) silt loam but contains a few thin layers of brown (10YR 5/3), loamy material; a few, fine, dark yellowish-brown (10YR 4/4) mottles; massive, but breaks to weak layers like the original strata of soil material that consisted of thin-bedded planes; friable; a few worm casts and pinholes; pH 7.0; diffuse boundary.

C2—30 to 60 inches, alternating bands of very dark grayish-brown (10YR 3/2) silt loam and of pale-brown (10YR 6/3) sandy loam 3 to 6 inches thick; within each band of sandy loam are very thin bands (less than one-eighth of an inch thick) of very dark grayish brown (10YR 3/2) silt loam; within the bands of silt loam are a few bands of dark-gray (10YR 4/1) material that is predominantly silt loam; a few, medium, yellowish brown (10YR 4/4) mottles; massive, but breaks to single grains and to chunks of various sizes; pH 7.0.

The A1 horizon ranges from loam to light silty clay loam in texture. When the A1 horizon is moist, its color ranges from dark grayish brown (10YR 4/2) to very dark grayish brown (10YR 3/2). When it is dry, its color ranges from grayish brown (10YR 5/2) to light brownish gray (10YR 6/2).

The profile in some areas of these soils, adjacent to Kennebec soils, shows weak layering, but the distinctness of the layers varies. Faint to distinct, grayish-brown to strong-brown mottles are common in the C horizons. Between a depth of 10 and 40 inches, the texture of the soil material is generally silt loam, but lenses of fine sandy loam are common. The texture of the soil material below a depth of 40 inches ranges from sandy loam to clay. The reaction ranges from slightly acid to neutral.

Nodaway silt loam (0 to 2 percent slopes) (No).—This soil is mainly along the major streams where improvement of the channel has eliminated frequent overflow. Some areas, however, are along small streams where flooding is normally not damaging to crops.

Included with this soil in mapping were areas of dark-colored soils that contain weak strata of soil material of different textures. The included soils are adjacent to areas of Kennebec soils.

This Nodaway soil is easily tilled. It is well suited to all the row crops, grasses, and legumes commonly grown in the county. Row crops can be grown year after year if all the crop residue is returned to the soil to help maintain the content of organic matter, if minimum tillage is practiced, and if an adequate amount of fertilizer is applied. (Capability unit I–1)

Nodaway silt loam, overflow (0 to 2 percent slopes) (Nw).—This soil is mainly along the smaller streams in the county and along the East Fork Grand River. It is distinctly stratified and is susceptible to flooding. The floodwaters frequently damage crops to some extent by causing scouring, depositing sediment, and making the soil excessively wet. Major channel improvement is needed in some places to overcome the hazard of flooding.

This soil is frequently used to grow row crops, but planting is delayed to avoid flooding early in spring. The crops are sometimes damaged by flooding, and this soil is sometimes too wet to be suitable for seeding small grains. Some areas are better suited to use for permanent pasture than to use for row crops. This soil is well suited to most grasses and legumes. (Capability unit IIIw–1)

Olmitz Series

The Olmitz series consists of dark-colored, moderately well drained soils that are gently sloping. These soils occur in narrow bands at the base of the uplands. They have developed under grasses and trees in local alluvium washed from sloping soils of the uplands.

The surface layer is dark-colored loam, generally 18 to 36 inches thick. The soil material beneath the surface layer is clay loam.

Available moisture capacity is high, the content of organic matter is moderate to high, and natural fertility is moderate. Permeability is moderate in the subsoil. The reaction is strongly acid to neutral in the surface layer and medium acid to strongly acid in the subsoil.

Profile of an Olmitz loam that has slopes of 4 percent (150 feet west and 300 feet north of the SE. corner of the NW¼NW¼ of section 36, T. 66 N., R. 31 W.):[5]

A11—0 to 10 inches, very dark grayish-brown (10YR 3/2) to very dark brown (10YR 2/2) loam; weak, fine, granular structure; friable; pH 6.0; clear boundary.

A12—10 to 17 inches, very dark grayish-brown (10YR 3/2) loam; moderate, fine, subangular blocky structure; friable; pH 6.0; clear boundary.

A3—17 to 27 inches, very dark gray (10YR 3/1) heavy loam; moderate, medium, subangular blocky structure; friable; pH 5.8; gradual boundary.

B1—27 to 33 inches, very dark gray (10YR 3/1) to very dark grayish-brown (10YR 3/2) light clay loam; weak, medium, subangular blocky structure; friable; pH 5.8; clear boundary.

B21—33 to 37 inches, very dark grayish-brown (10YR 3/2) clay loam; common, fine, dark grayish-brown (2.5Y 4/2) and yellowish-brown (10YR 5/6) mottles; moderate, medium, subangular blocky structure; friable to firm; pH 5.8; clear boundary.

B22—37 to 42 inches, dark grayish-brown (2.5Y 4/2) clay loam; a few, fine, strong-brown (7.5Y 5/6) and dark reddish-brown (5YR 3/4) mottles; moderate, medium, subangular blocky structure; friable to firm; pH 5.8; gradual boundary.

B3—42 to 52 inches, dark grayish-brown (10YR 4/2) clay loam; many, medium, dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; friable to firm; pH 6.0; gradual boundary.

C—52 to 58 inches, grayish-brown (2.5Y 5/2) clay loam; many, large, yellowish-brown (10YR 5/4) mottles; massive; friable to firm; black concretions common; pH 6.0.

The A horizons range from black (10YR 2/1) to very dark grayish brown (10YR 3/2) in color, from loam to silt loam in texture, and from 18 to 36 inches in combined thickness. The B horizons range from very dark gray (10YR 3/1) to grayish brown (2.5Y 5/2) in color and from heavy loam to heavy clay loam in texture. The mottling in the B horizons ranges from strong brown of 7.5YR hue to reddish brown or dark reddish brown of 5YR hue. The B horizons are normally medium acid, but the reaction ranges from strongly acid to slightly acid because of the influence of local wash from nearby hills.

Olmitz loam, 2 to 5 percent slopes (OaB).—The color of this soil varies, depending on the characteristics of the adjacent soils of the uplands. Where this soil is at the base of slopes occupied by Shelby soils, it is dark colored. Where it occurs at the base of slopes occupied by Gara soils, it is generally lighter colored. Also, this soil is at the base of steep slopes in some places and is stony. The slopes are generally less than 5 percent, but in some areas they are as steep as 9 percent. They are generally short but are long and very gentle in some places, mainly where this soil occurs on alluvial fans. The soil material is dark colored to a depth of 4 to 5 feet where the slopes are long.

This soil is well suited to all the crops commonly grown in the county. In places it is subject to erosion caused by runoff from the adjacent uplands, but diversion terraces can generally be used to protect those areas. Surface drainage is adequate in most places. This soil contains seepage spots, however, that make wetness a slight hazard. Erosion is the major hazard if this soil is farmed. (Capability unit IIe-1)

Olmitz-Kennebec complex, 0 to 5 percent slopes (OkB).—These nearly level to gently sloping soils are in upland drainageways and on bottoms along streams. Olmitz soils make up about 60 percent of the acreage. They are gently sloping and are at the base of upland slopes where they receive deposits of soil material from the slopes above. They occupy narrow, continuous bands on either side of the watercourse. Kennebec soils, in nearly level areas of the watercourse, make up about 30 percent of the acreage in the mapping unit. In many places the areas of Kennebec soils are less than 100 feet wide and are cut by gullies.

Included with these soils in mapping were areas of a dark-colored soil that is similar to the Wabash soils but that is moderately fine textured throughout the profile. Also included were areas of a Nodaway soil formed in stratified alluvium. Both of the included soils occur with the Kennebec soils on narrow flood plains. They occupy about 10 percent of the acreage in the mapping unit.

Areas of this complex are generally too small and narrow for farming as individual fields. In places the soils are farmed with the adjacent sloping soils of the uplands. Because of the hazard of gullying, the areas in the drainageways should be left in grass. In many places, however, they already contain gullies. Where gullying has occurred, the gullies should be worked in and seeded to suitable grasses so that a proper outlet will be provided for runoff from the uplands. (Capability unit IIe-1)

Pershing Series

The Pershing series consists of moderately dark colored, somewhat poorly drained, gently sloping to moderately sloping soils that have developed in loess. It is believed that these soils developed under tall prairie grasses and that more recently trees invaded. The soils are on uplands and on bench terraces, mainly in the eastern part of the county.

The soil material in the uppermost 10 inches is silt loam. It is very dark grayish brown in the upper part and grayish brown in the lower part. The upper part of the subsoil is dark-brown silty clay loam that has coatings of light gray on the peds, or is mottled with grayish brown. The lower part is silty clay that is dark grayish brown but grades to grayish brown with increasing depth.

The subsoil is slowly permeable. Available moisture capacity is high, and natural fertility is moderate to low. Reaction ranges from slightly acid in the surface layer to very strongly acid in the subsoil. Erosion is a hazard.

Cultivated crops are grown on part of the acreage, and some areas are used for pasture. A few areas still have a sparse cover of trees.

[5] This profile has colors of lower chroma and contains more mottles than is considered typical for the Olmitz series.

Representative profile of a Pershing silt loam that has slopes of about 4 percent (about 1 mile northwest of Allendale in the NE¼NW¼ of section 28, T. 66 N., R. 30 W.):

Ap—0 to 6 inches, very dark grayish brown (10YR 3/2) silt loam that is gray (10YR 5/1) when dry; moderate, fine, granular structure; friable; pH 6.2; abrupt boundary.

A2—6 to 10 inches, dark grayish-brown (10YR 4/2) to grayish-brown (10YR 5/2) silt loam; weak, thin, platy structure that breaks to moderate, fine, granular structure in the lower part of the horizon; light-gray (10YR 7/2) silt coatings are on the surfaces of the peds; pH 5.6; clear boundary.

B1t—10 to 15 inches, dark-brown (10YR 3/3) silty clay loam; moderate, fine, subangular blocky structure; friable to firm; the surfaces of the peds are partly coated with light-gray (10YR 7/2) silt and thin, patchy clay films; pH 5.2; clear boundary.

B21t—15 to 18 inches, dark grayish-brown (10YR 4/2) medium silty clay; few, fine, dark yellowish-brown (10YR 4/4) mottles; very fine, strong, angular blocky and subangular blocky structure; firm; thick clay films; a few, fine, black concretions; pH 5.0; clear boundary.

B22t—18 to 24 inches, dark grayish-brown (10YR 4/2) to grayish-brown (10YR 5/2) light to medium silty clay; few to common, small, yellowish brown (10YR 5/4) mottles; fine, strong, angular blocky and subangular blocky structure; firm; thick clay films; a few, fine concretions of iron and manganese; pH 5.0; clear boundary.

B23t—24 to 34 inches, grayish-brown (2.5Y 5/2) light silty clay; common, fine, yellowish-brown (10YR 5/8) mottles and a few, coarse, gray (N 5/0) mottles; moderate to weak, fine, subangular blocky structure; firm; clay films; common, fine concretions of iron and manganese; pH 5.4; gradual boundary.

B3—34 to 46 inches, grayish-brown (2.5Y 5/2) heavy silty clay loam; many, medium, dark yellowish-brown (10YR 4/4) mottles and a few, coarse, yellowish-brown (10YR 5/8) mottles; weak, fine, subangular blocky structure; firm; some clay films; pH 6.6; gradual boundary.

C—46 to 56 inches, grayish-brown (2.5Y 5/2) and dark yellowish brown (10YR 4/4) light to medium silty clay loam; a few, coarse, light brownish-gray (2.5Y 6/2) mottles; massive; firm; contains some black stains and concretions of iron and manganese; pH 6.6.

When the soil is moist, the color of the Ap or A1 horizon ranges from dark grayish brown (10YR 4/2) or very dark grayish brown (10YR 3/2) to very dark gray (10YR 3/1). When the soil is dry, the color of the Ap or A1 horizon ranges from gray (10YR 5/1) or grayish brown (10YR 5/2) to light brownish gray (10YR 6/2). The A2 horizon ranges from 2 to 6 inches in thickness and from dark grayish brown (10YR 4/2) to light brownish gray (10YR 6/2) or gray (10YR 6/1) in color. In cultivated fields, the A1 and A2 horizons have been mixed in the plow layer and the plow layer is very dark grayish brown (10YR 3/2) or dark grayish brown (10YR 4/2).

Where these soils are on benches, the B1t horizon is several inches thicker than where they are on uplands. The texture of the B2 horizons ranges from light silty clay to heavy silty clay. The B horizons have colors in 10YR and 2.5Y hues, with values of 4 and 5 and a chroma of 2. In most places the mottles are yellowish brown or strong brown, but in the lower horizons the color of some mottles is neutral gray. Small oxide concretions occur throughout the subsoil.

The texture of the C horizon is silty clay loam. In most places the dominant colors in the C horizon are grayish brown and dark yellowish brown or strong brown.

Pershing silt loam, 2 to 5 percent slopes (PeB).—This soil occurs with Keswick and Ladoga soils on ridgetops in the uplands. It lies above steeper areas of Gara soils.

This soil is suited to cultivation, and crops grown on it respond well if fertilizer is applied. The areas are generally too long and narrow to be managed as individual fields, and this soil is usually farmed with the adjacent soils. If cultivated crops are grown, installing terraces and tilling on the contour help to control erosion. (Capability unit IIe–6)

Pershing silt loam, 2 to 5 percent slopes, moderately eroded (PeB2).—This gently sloping soil is on ridgetops. In most places it is moderately eroded, but erosion is severe in some places. The plow layer is low in content of organic matter. It consists partly of material from the original surface layer and partly of material from the subsurface layer.

This soil is subject to further erosion and should be protected if it is cultivated. Crops grown on it respond well to applications of lime and fertilizer. Maintaining good tilth is difficult if farming is intensive. (Capability unit IIIe–6)

Pershing silt loam, 5 to 9 percent slopes (PeC).—This soil is on the uplands. It contains a moderate amount of organic matter. Small areas of Keswick soils were included with it in mapping.

Most of the acreage is cultivated, but erosion is a hazard where cultivated crops are grown. Practices that control erosion are needed. (Capability unit IIIe–6)

Pershing silt loam, 5 to 9 percent slopes, moderately eroded (PeC2).—Areas of this soil contain some small spots where erosion has been severe. Further erosion is a hazard, and the content of organic matter and natural fertility are low. If crops are grown, or if this soil is used for pasture, large amounts of lime and fertilizer are needed. (Capability unit IIIe–6)

Pershing silt loam, benches, 2 to 5 percent slopes (PrB).—This soil occurs on benches with Ladoga and Grundy soils. Its surface layer is 6 to 10 inches thick. Erosion is a hazard, but this soil is suitable for row crops, small grains, and meadow. (Capability unit IIe–6)

Pershing silt loam, benches, 2 to 5 percent slopes, moderately eroded (PrB2).—The surface layer of this soil is dark grayish brown and is less than 7 inches thick. In some places all of the surface layer has been removed by erosion and the subsoil is exposed.

Lime and fertilizer are needed if this soil is used for crops. Further erosion is a serious hazard if cultivated crops are grown. (Capability unit IIIe–6)

Pershing silt loam, benches, 5 to 9 percent slopes, moderately eroded (PrC2).—This soil is on ridgetops and side slopes in the eastern part of the county. It is moderately eroded in most places but is severely eroded in some places and only slightly eroded in a few others. The plow layer is dark grayish-brown heavy silt loam or light silty clay loam and is underlain by dark grayish-brown silty clay.

This soil is poorly suited to cropping and is subject to sheet and gully erosion. Crops grown on it need lime and fertilizer. (Capability unit IIIe–6)

Pershing and Grundy soils, benches, 5 to 9 percent slopes, severely eroded (PsC3).—This undifferentiated unit consists of severely eroded Pershing and Grundy soils. Sheet erosion has removed all of the original surface layer, and these soils contain some shallow gullies.

In most places the plow layer is silty clay loam. Because erosion has been uniform, however, some included areas have a surface layer of silt loam or of silty clay. In the Pershing soils, the plow layer is dark grayish brown, and in the Grundy soils, it is very dark grayish brown. The subsoil is about the same color as the plow layer but is slightly darker colored in the Grundy soils than in the

Pershing. A detailed description of a Grundy profile is given under the Grundy series.

The soils of this unit are not well suited to row crops. They are difficult to till, and a good seedbed is hard to prepare. (Capability unit IVe–6)

Sharpsburg Series

The Sharpsburg series consists of dark-colored, moderately well drained soils that are gently sloping to moderately sloping. These soils are mainly on divides and high ridgetops, but they occur to a lesser extent in other areas of uplands. A small acreage is on benches. The soils on divides and high ridgetops are gently sloping, and those on the other areas of uplands are moderately sloping. The eastern boundary of the areas is adjacent to areas of Grundy soils and lies between the East Fork and the Middle Fork of the Grand River. The Sharpsburg soils have developed in loess. In the areas on uplands, they are underlain by glacial till at a depth of 3 to 8 feet. In the areas on benches, they are underlain by stratified alluvium at a depth of 4 to 10 feet.

The surface layer is very dark brown silt loam 7 to 18 inches thick. The upper part of the subsoil is brown or dark-brown silty clay loam. The lower part is mottled silty clay loam that is mainly dark grayish brown but grades to grayish brown with increasing depth.

Permeability is moderately slow, and the available moisture capacity and natural fertility are high. The content of organic matter is also high in areas that are not eroded. The uppermost layers in the profile are slightly acid, but the soil material grades to strongly acid in the subsoil. Erosion is the most serious hazard to farming.

These soils are well suited to all the row crops, small grains, and legumes commonly grown in the county. Most of the acreage is cultivated.

Representative profile of a Sharpsburg silt loam that has slopes of 3 percent (50 feet east of the SW. corner of the SE¼SE¼ of section 26, T. 66 N., R. 31 W.):

Ap—0 to 7 inches, very dark brown (10YR 2/2) silt loam, dark gray (10YR 4/1) when dry; very dark grayish brown (10YR 3/2) if crushed; weak, fine, granular structure; friable; many fine roots, worm casts, and small pores; pH 6.4; clear, smooth boundary.

B1—7 to 13 inches, dark-brown (10YR 3/3) medium silty clay loam, grayish brown (10YR 5/2) when dry; moderate, very fine, subangular blocky structure; friable; peds have very dark brown (10YR 2/2) coatings in places; many fine roots, worm casts, and small pores; pH 6.0; gradual, smooth boundary.

B21t—13 to 20 inches, brown (10YR 4/3) heavy silty clay loam; moderate, fine, subangular blocky structure; firm to friable; thin, shiny clay films on the surfaces of the peds; many fine roots; pH 5.4; clear, smooth boundary.

B22t—20 to 28 inches, dark grayish-brown (10YR 4/2) heavy silty clay loam; common, fine, faint, grayish-brown (10YR 5/2) mottles and distinct, yellowish-brown (10YR 5/4) mottles; moderate, medium, subangular blocky structure; firm; shiny clay films on the surfaces of the peds; contains a few, small, black concretions, a few stains, and a few fine roots; pH 5.0; clear, smooth boundary.

B3t—28 to 38 inches, grayish-brown (2.5Y 5/2) medium silty clay loam; common, medium, dark grayish-brown (10YR 4/2) mottles; weak to moderate, medium, prismatic structure breaking to moderate, medium, subangular blocky structure; firm; shiny clay films cover some of the ped surfaces; many, small, black concretions; pH 5.8; gradual boundary.

C—38 to 60 inches, grayish-brown (2.5Y 5/2) and dark yellowish-brown (10YR 4/4) silty clay loam; weak, coarse, prismatic structure to massive; friable when moist and slightly hard when dry; clay films appear along the major cleavage planes; many, small, black concretions and stains; pH 6.2.

The A1 or Ap horizon ranges from black (10YR 2/1) or very dark brown (10YR 2/2) to dark grayish brown (10YR 3/2) in color and from medium to heavy silt loam in texture. The B horizons range from brown (10YR 4/3 or 5/3) to grayish brown (10YR 5/2) or dark grayish brown (10YR 4/2) in color and from medium silty clay loam to light silty clay in texture. In this county the B3t horizon of these soils has colors of lower chroma and contains more mottles than is typical for the Sharpsburg series. The areas where the B horizons are dark grayish brown are adjacent to areas of Grundy soils and have a finer texture than is typical in other areas. In most places the subsoil is strongly acid.

Sharpsburg silt loam, 2 to 5 percent slopes (SoB).—This soil occurs in continuous strips along the major divides and ridgetops in the eastern part of the county, above areas of Lagonda, Adair, and Shelby soils. In terraced fields it generally occupies the areas above the first terrace. The slopes are short and convex.

This soil is only slightly susceptible to erosion, and it is well suited to corn, soybeans, small grains, and legumes. It is generally used for cultivated crops and meadow. Protection from erosion is needed if field crops are grown. (Capability unit IIe–6)

Sharpsburg silt loam, 2 to 5 percent slopes, moderately eroded (SoB2).—This soil is widely distributed throughout the county but does not occupy a large acreage. Erosion has removed part of the dark-colored surface layer, and the present surface layer is less than 7 inches thick. In some areas all of the original surface layer has been lost.

Though this soil has lost part of its surface layer, it is still well suited to crops. If it is farmed, however, practices are needed that help to control erosion. (Capability unit IIe–6)

Sharpsburg silt loam, 5 to 9 percent slopes (SoC).—This moderately sloping soil is on the sides of ridgetops and on the lower side slopes of ridges above soils on flood plains and terraces. The layer of loess in which it has developed ranges from 3 to 5 feet in thickness.

Included with this soil in mapping were some areas of soils that have developed in sediment of gritty silt loam and that occur at lower elevations than the Sharpsburg soil. Erosion is a hazard if this Sharpsburg soil is farmed. (Capability unit IIIe–6)

Sharpsburg silt loam, 5 to 9 percent slopes, moderately eroded (SoC2).—This soil is on ridgetops and on the side slopes of ridges. In most places it has moderate slopes, but some areas in which the slopes are as steep as 12 percent were included in mapping.

This Sharpsburg soil has developed in loess, but glacial till is within 3 feet of the surface in places because erosion has removed so much of the soil material. Sheet erosion has removed most of the original surface layer, and the present surface layer is only 3 to 7 inches thick. Further erosion is a major hazard. (Capability unit IIIe–6)

Sharpsburg silt loam, benches, 3 to 8 percent slopes (SbC).—This soil is on benches bordering the major streams. It generally occurs with Grundy soils, but in a few places it occurs with Pershing, Ladoga, and Edina soils. In some places this soil lies above areas of steep Ter-

race escarpments. It has developed in a layer of loess 4 to 10 feet thick and is underlain by stratified alluvium. The slopes are mainly gentle to moderate. Included in mapping, however, were some areas in which the slopes are steeper than 8 percent. Also included were areas where moderate erosion has occurred.

If this Sharpsburg soil is well managed and is protected from erosion, it is suited to the crops commonly grown in the county. Erosion is the major hazard to farming. (Capability unit IIe-6)

Sharpsburg soils, 5 to 9 percent slopes, severely eroded (SgC3).—The plow layer of these soils is dark grayish-brown to brown silty clay loam. The substratum is heavily mottled and is within 15 to 18 inches of the surface.

These soils can be cultivated but are not well suited to row crops. The acreage is so small, however, that the soils are generally managed with the adjacent soils. They need protection from further erosion. (Capability unit IVe-6)

Shelby Series

Dark-colored, moderately well drained soils of the uplands make up the Shelby series. These soils are strongly sloping to very steep and have developed in glacial till under a cover of prairie grasses. They lie below areas of Adair, Lagonda, and Clarinda soils and are also at a lower elevation than the Sharpsburg and Grundy soils that have formed in loess. The slopes are similar to those of the Gara soils, but these soils are not adjacent to the major streams as are the Gara soils.

In areas that are not eroded, the surface layer is dark colored and is 10 to 20 inches thick. The upper part of the subsoil is yellowish-brown clay loam. The lower part is yellowish-brown or brown clay loam mottled with dark grayish brown or grayish brown.

The Shelby soils have moderate to moderately slow permeability, moderate available moisture capacity, and moderate natural fertility. In areas that are not eroded, they have a moderate to high content of organic matter. These soils are slightly acid to strongly acid to a depth of about 3 feet and are neutral to calcareous below that depth. Runoff is very rapid, and erosion is a serious hazard if these soils are cultivated.

Where these soils have slopes of more than 14 percent, they should be kept in permanent vegetation. Many of the less sloping areas are cultivated.

Representative profile of a Shelby loam that has slopes of 15 percent (near the NE. corner of the NW¼ of section, 27, T. 65 N., R. 32 W.):

A1—0 to 8 inches, black (10YR 2/1) loam; very dark grayish brown (10YR 3/2) if crushed; strong, medium, granular structure; friable; many fine roots; pH 6.8; gradual boundary.

A3—8 to 13 inches, very dark grayish-brown (10YR 3/2) light clay loam, with some mixing of yellowish brown (10YR 5/4); strong to moderate, fine, subangular blocky structure; friable; contains much fine gravel; many fine roots; pH 6.8; gradual boundary.

B1—13 to 20 inches, yellowish-brown (10YR 5/4) and very dark grayish-brown (10YR 3/2) clay loam; moderate, fine, subangular blocky structure; firm; many fine roots; pH 6.2; gradual boundary.

B21t—20 to 25 inches, yellowish brown (10YR 5/4) clay loam; a few, dark grayish-brown (10YR 4/2) streaks; moderate, medium, subangular blocky structure; firm; occasional fine roots; pH 6.4; gradual boundary.

B22t—25 to 31 inches, yellowish-brown (10YR 5/4) clay loam; a few, dark yellowish brown (10YR 4/4) and common, medium, grayish-brown (2.5Y 5/2) mottles; moderate, fine, subangular blocky structure; firm; pH 6.8; clear boundary.

B3—31 to 46 inches, gray (10YR 6/1) and brown (10YR 5/3) clay loam; a few, coarse, yellowish brown (10YR 5/8) mottles; moderate, medium, subangular blocky structure; firm; pH 7.0; gradual to diffuse boundary.

C—46 to 60 inches, grayish-brown (2.5Y 5/2) and yellowish-brown (10YR 5/4) light clay loam; common to many, medium to coarse mottles of dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/8), and gray (10YR 6/1); moderate, medium, subangular blocky structure; firm; occasional concretions of iron and lime; calcareous in a few places.

The color of the A1 horizon ranges from black (10YR 2/1) to dark grayish brown (10YR 3/2). The texture of that horizon is generally loam in areas that are not eroded. The B horizons range from dark brown (10YR 4/3) to yellowish brown (10YR 5/6) in color and from light to heavy clay loam in texture. The B3 horizon is more grayish than typical for Shelby soils. Calcareous glacial till is at depths ranging from 4 to 6 feet. The content of gravel and stones in the till is variable, and pockets of sand are common.

Shelby loam, 9 to 14 percent slopes (ShD).—This soil lies above areas of Olmitz and other soils of drainageways and colluvial slopes. It lies below areas of Adair soils on till plains and Sharpsburg and Grundy soils on ridgetops. Included in mapping were small areas of Adair soils. The surface layer is dark colored and is 7 to 15 inches thick.

This soil has a moderate to high content of organic matter but is subject to erosion. It is poorly suited to frequent cultivation and has not been intensively cultivated. (Capability unit IVe-6)

Shelby loam, 9 to 14 percent slopes, moderately eroded (ShD2).—This sloping soil occurs with Adair soils on uplands. It has been cultivated or pastured extensively and has lost all but 3 to 6 inches of its original surface layer through erosion. Included with it in mapping were some areas of Adair soils that have a finer textured subsoil than typical for Shelby soils.

This Shelby soil is susceptible to further erosion. Response is good to applications of fertilizer and lime. (Capability unit IVe-6)

Shelby loam, 14 to 20 percent slopes (ShE).—In most places this soil is downslope from Adair soils. Many of the areas have never been plowed. As a result, most of the original surface layer remains.

In places this soil is partly covered by brush and young trees, but it has been used primarily for pasture. It is not suitable for row crops, and all tillage needed to establish vegetation should be on the contour. If fertilizer is applied, a number of grasses and legumes can be grown. Pasture and hay are suitable uses, and this soil is suitable for trees. (Capability unit VIe-6)

Shelby loam, 14 to 20 percent slopes, moderately eroded (ShE2).—This soil lies below the Adair soils and above Olmitz and other soils of drainageways and bottom lands. Cultivation or overgrazing has resulted in the loss of much of the original surface layer.

Except when a pasture needs to be renovated, this soil is too steep and susceptible to erosion for cultivation. It is suitable for pasture, hay, or trees. (Capability unit VIe-6)

Shelby loam, 20 to 30 percent slopes (ShF).—Even in areas that are not eroded, the surface layer of this soil is only 5 to 10 inches thick. The other soil layers are thin, and the total thickness of the soil profile is less than that

of the profile described for the Shelby series. In many places calcareous glacial till is within 4 feet of the surface. Runoff is very rapid, and the amount of water absorbed by this soil is small.

Some areas of this soil have a cover or partial cover of young trees, mainly hickory, elm, hawthorn, prairie crabapple, Osage-orange, and a few oaks. The present stands are unproductive. The areas provide beneficial cover for wildlife but are undesirable for pasture. If this soil is used for pasture, the brush should be removed and long-lived grasses and legumes should be encouraged. Trees are an alternate crop that could be considered. (Capability unit VIIe–6)

Shelby and Gara soils, 9 to 20 percent slopes, severely eroded (SrE3).—This undifferentiated unit consists of Shelby and Gara soils that have lost most of their original surface layer through sheet erosion. The subsoil, which is yellowish brown, is exposed in most places, and some areas are gullied. Part of the original surface layer remains in small areas, but the texture of the present surface layer is clay loam in most places. In about 75 percent of the acreage, the slopes are between 9 and 15 percent.

These soils are too steep and susceptible to further erosion for cropping, and brush has grown up in some areas. The gullies should be smoothed and seeded to long-lived, adapted grasses and legumes. Lime and fertilizer are also needed. When a pasture is renovated, tillage ought to be on the contour. These soils are well suited to trees. (Capability unit VIe–6)

Terrace Escarpments

Terrace escarpments (Te) is a miscellaneous land type that rises from 10 to 50 feet above the present flood plains. It is below areas of gently sloping Grundy, Sharpsburg, Pershing, Ladoga, and Edina soils on benches, and in places the areas include short slopes of 10 to 30 percent that are a part of the benches.

This land type varies widely in characteristics. The soil material near the surface is medium textured and is very dark grayish brown to brown. In places it is underlain by a layer of lighter colored soil material that, in turn, is underlain by silty clay to loamy sand. The soil material to a depth of 12 to 18 inches was probably derived from loess. Below the loessal material is old alluvium that is stratified in most places below a depth of 3 to 4 feet. The soil material is generally strongly acid.

This land type is easily eroded and should remain in permanent pasture, meadow, or trees. The original vegetation was trees, and some areas have remained in trees. (Capability unit VIe–6)

Wabash Series

The Wabash series consists of dark-colored, poorly drained soils that developed in fine-textured sediment. These soils are on flood plains, in many places along the Platte River and the Middle Fork and West Fork of Grand River. They are in nearly level areas or depressions but are generally not adjacent to either the original stream channel or the uplands. Some areas are ponded unless artificial drainage is provided. The native vegetation was mostly grasses and some deciduous hardwoods that tolerate water.

The surface layer is very dark gray or black heavy silt loam to clay. It is underlain by black or very dark gray clay that extends to a depth of 2 feet or more. The substratum consists of dark-gray clay.

Permeability is very slow in the lower part of the profile. The available moisture capacity and natural fertility are high, and the content of organic matter is very high. Reaction is medium acid to slightly acid throughout the profile.

Row crops are grown extensively on these soils, but artificial drainage is needed in many places. Tile drains do not work satisfactorily, because of the restricted movement of water through the clay.

Representative profile of Wabash silty clay loam on a north-facing riverbank (near the SW. corner of the SE¼SW¼ of section 8, T. 65 N., R. 31 W.):

A11—0 to 5 inches, very dark gray (10YR 3/1) silty clay loam; moderate, fine, granular structure; friable; pH 5.8; clear boundary.

A12—5 to 13 inches, black (10YR 2/1) heavy silty clay loam; moderate, medium, subangular blocky and angular blocky structure; friable to firm; pH 5.8; clear boundary.

A13—13 to 21 inches, black (N 2/0) silty clay; strong to moderate, very fine, subangular blocky structure; firm; pH 5.6; gradual boundary.

B2—21 to 31 inches, black (10YR 2/1) clay; moderate, fine, subangular blocky structure; very firm; pH 5.6; gradual boundary.

B3—31 to 48 inches, very dark gray (10YR 3/1) clay; moderate, very fine to fine, subangular blocky structure; contains large cleavage planes; very firm when moist, plastic when wet; pH 6.8; diffuse boundary.

C—48 to 56 inches, dark-gray (10YR 4/1) clay; weak, very fine, subangular blocky structure; contains large cleavage planes; very plastic when wet; common, small concretions, some of which are dark colored; pH 7.0.

In areas that are not covered by a layer of overwash, the A1 horizons range from very dark gray (10YR 3/1) to black (10YR 2/1) in color and from heavy silt loam to clay in texture. In areas that are covered by a layer of overwash, the color of the A1 horizons ranges from dark grayish brown (10YR 4/2) to very dark grayish brown (10YR 3/2). Silty clay or clay is at a depth of less than 20 inches. The color of the B horizons ranges from very dark gray (10YR 3/1 or N 3/0) to black (10YR 2/1 or N 2/0), and those horizons extend to a depth of 2 feet or more. In places the B horizons contain mottles of gray and yellowish brown. The soil material becomes lighter colored with increasing depth.

Wabash silty clay (0 to 2 percent slopes) (Wa).—This soil has a surface layer of silty clay or clay and lower horizons of clay. In most places it is in depressions in wide flood plains, within larger areas of Wabash silty clay loam. Flooding occurs occasionally, but improvements in the stream channel have almost eliminated this hazard. Because this soil is so wet, it was one of the last soils of the bottom lands to be cultivated.

This soil is used mainly for row crops, but surface drainage is needed in most places for cropping to be profitable. After drainage is provided, this soil is well suited to soybeans, small grains, and most grasses and legumes. Because of wetness and unfavorable soil characteristics, this soil is poorly suited to alfalfa, bromegrass, and corn. Tillage is difficult, and the soil material breaks into clods that do not make a good seedbed. Fall plowing is better than plowing in spring. (Capability unit IIIw–14)

Wabash silty clay loam (0 to 2 percent slopes) (Wb).—This soil occupies large areas on the major flood plains of the county. It generally lies between areas of Olmitz

soils near the uplands and areas of Nodaway and Kennebec soils near the stream channel. Where this soil is on bottoms along small streams, it is in a narrow band between the stream channel and the uplands.

In most places the texture is silty clay loam to a depth of 7 to 20 inches, but it is loam or silt loam in places. The lower part of the profile is clay to silty clay.

Included in mapping were areas of a soil that is similar to this soil but that has a light-colored subsurface layer. Also included are areas of a soil that resembles the Wabash soils but that has a texture of silty clay loam throughout the entire profile. Other inclusions consist of small areas of Olmitz soils that are mainly gently sloping and are on bottoms along small streams.

Most crops commonly grown in the county can be grown on this Wabash soil. Drainage is needed in some areas. (Capability unit IIw-1)

Use and Management of the Soils

This section has several main parts. In the first, uses of the soils for crops and pasture are briefly discussed, the system of capability classification used by the Soil Conservation Service is explained, and predicted average acre yields of the principal crops and pasture are given. In the second, uses of the soils as woodland are described. Then, uses of the soils for wildlife and for engineering are discussed.

Use of the Soils for Crops and Pasture

In this part of the soil survey, capability grouping of soils is defined and the soils are placed in capability units. Suggestions for the use and management of the soils for crops and pasture are given.

Most of the soils in the county are farmed. Some wheat is grown, but the main crops are corn, soybeans, oats, alfalfa, red clover, bromegrass, orchardgrass, tall fescue, and timothy.

In most places the soils have at least moderate slopes, and for these sloping soils contour farming, terraces, waterways, and proper management of crop residue help to conserve moisture and to control erosion. Dams in the larger drainageways can be used to stabilize outlets for runoff and help to control flooding. In about half of the acreage of bottom-land soils, wetness is a hazard to crops. Surface ditches help to drain off the excess water in those soils, and tile drains can be used where the soils are suitable. Diversion terraces can also be used to protect some areas from runoff. The amount of lime and the kinds and amounts of fertilizer to apply should be determined by testing the soils.

Capability groups of soils

Capability classification is the grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment. The classification does not apply to most horticultural crops, or to rice and other crops that have their special requirements. The soils are classified according to degree and kind of permanent limitation, but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils; and without consideration of possible but unlikely major reclamation projects.

In the capability system, all kinds of soils are grouped at three levels, the capability class, subclass, and unit. These are discussed in the following paragraphs.

Capability Classes, the broadest grouping, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I. Soils have few limitations that restrict their use.

Class II. Soils have some limitations that reduce the choice of plants or require moderate conservation practices.

Class III. Soils have severe limitations that reduce the choice of plants or require special conservation practices, or both.

Class IV. Soils have very severe limitations that restrict the choice of plants, require very careful management, or both.

Class V. Soils subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover. (None in Worth County)

Class VI. Soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.

Class VII. Soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife.

Class VIII. Soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes. (None in Worth County)

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in some parts of the United States but not in Worth County, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V (none in Worth County) can contain, at the most, only subclasses indicated by *w*, *s*, and *c*, because the soils in it are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

Capability Units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a

convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-1 or IIIw-1. Thus, in one symbol, the Roman numeral designates the capability class or degree of limitation, and the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph. The Arabic numeral specifically identifies the capability unit within each subclass.

In the following pages, the capability units in Worth County are described and suggestions for the use and management of the soils are given. The capability units are not numbered consecutively but are numbered according to a statewide system, and not all of the capability units used in Missouri are represented in this county. The names of soil series represented are mentioned in the description of each capability unit, but this does not mean that all the soils of a given series appear in the unit. To find the names of all of the soils in any given capability unit, refer to the "Guide to Mapping Units" at the back of this survey.

CAPABILITY UNIT I-1

This capability unit consists of deep, well-drained Kennebec and Nodaway soils that have a surface layer of silt loam and are friable throughout. These nearly level soils are on bottom lands. They are not subject to erosion, and wetness is not a hazard to farming. Flooding occurs occasionally, but damage to crops is minor.

These soils are naturally fertile and are easy to cultivate. They have high available moisture capacity, are moderately permeable, and have a medium to high content of organic matter.

The soils of this unit are suited to all the crops commonly grown in the county. Corn, soybeans, oats, and wheat are the main crops, but alfalfa is grown to some extent. The soils can also be used for grasses or trees, and they are suitable for development as wildlife habitat. Because of the high cash return, however, the soils are generally used for row crops. Their chief management needs are keeping the surface soil open so that it will absorb water and maintaining the supply of plant nutrients and the content of organic matter.

Turning under crop residue and growing winter cover crops and crops for green manure will help to maintain the content of organic matter. Keeping tillage to a minimum helps to protect the soil structure from breakdown.

A suitable cropping system is 3 years of row crops and 1 year of a small grain, with a cover crop grown in fall and winter to turn under as green manure. Grading or smoothing the undulating areas makes tillage easier and provides a field surface suitable for applying irrigation water.

Large amounts of lime and fertilizer are generally not needed on these soils. A starter fertilizer is needed, however, and a maintenance fertilizer should be applied.

CAPABILITY UNIT IIe-1

Deep, dark-colored, moderately well drained Olmitz and Kennebec soils are in this capability unit. Some areas of these soils are on bottom lands, generally adjacent to uplands, where they receive additions of colluvial material from the slopes above. Others are on alluvial fans or in upland drainageways. The slopes are gentle and are normally short.

These soils are naturally fertile and are easy to cultivate. They have high available moisture capacity, moderate permeability, and a medium to high content of organic matter. These soils are slightly eroded in places and are susceptible to further erosion if they are not protected.

The soils of this unit are suited to all the field crops commonly grown in the county, but corn, soybeans, oats, wheat, and alfalfa are the main crops. The soils can also be used for grass and trees and are suitable for development for wildlife habitat. They are generally not used for trees and for wildlife habitat, however, because of the high cash return from field crops. The principal management needs consist of protecting the soils from runoff and erosion and maintaining the content of organic matter, the supply of plant nutrients, and good soil tilth.

If runoff is controlled, farming on the contour is generally adequate for protecting these soils from erosion. In many places terraces or diversions, waterways, and contour farming are necessary to control runoff on the adjacent slopes. The soils are suitable for waterways that provide outlets for runoff. Winter cover crops, green-manure crops, and crop residue can be used to protect these soils and to maintain the content of organic matter and good soil tilth.

A suitable cropping system is 3 years of row crops and 1 year each of a small grain and meadow. Row crops and small grains can be grown year after year, however, if the soils are managed intensively. Where these crops are grown year after year, the management should include contour farming, growing a cover crop when the soil would otherwise be bare, keeping crop residue on the surface or turning it under, and applying fertilizer as needed.

CAPABILITY UNIT IIe-6

This capability unit consists of deep, moderately well drained and somewhat poorly drained, gently sloping Adair, Grundy, Ladoga, Pershing, and Sharpsburg soils on ridgetops and benches. These soils have a dark-colored surface layer 6 to 14 inches thick. They are slightly or moderately eroded in places.

These soils have fairly high natural fertility, are easily tilled, and are medium to high in content of organic matter. The available moisture capacity is moderate to high, and permeability is moderately slow or slow. All of these soils are susceptible to further erosion unless they are properly managed.

The soils of this unit are suited to all the crops commonly grown in the county. Wheat and oats are commonly grown, but corn is the major row crop. Part of the acreage is in soybeans, however, and a large acreage is in other legumes and in grasses. Alfalfa grown on these soils is subject to damage from heaving caused by frost action. In general, these soils are not well suited to trees, probably because of their high content of organic matter in the surface layer, the thickness of their surface layer, and their position on ridgetops. The major management needs consist of controlling erosion and maintaining the content of organic matter, the supply of plant nutrients, and good soil tilth.

Managing crop residue well and growing winter cover crops and green-manure crops help to protect these soils from erosion and to maintain the content of organic matter and good tilth. Terraces, waterways, and contour farming also help to control runoff and erosion.

If these soils are terraced, a suitable cropping system is 3 years of row crops and 1 year each of a small grain and meadow. Where terraces have not been constructed, the soils should be kept in meadow for a longer time and row crops grown a shorter time.

CAPABILITY UNIT IIw-1

This unit consists of deep, dark-colored, somewhat poorly drained and poorly drained Edina, Grundy, Nevin, and Wabash soils that are nearly level. These soils are on benches, terraces, and bottoms along streams. Erosion is not a major hazard.

Natural fertility is fairly high, and these soils are easily tilled and commonly have a high content of organic matter. Available moisture capacity is moderate to high, and permeability is slow.

These soils are suited to corn and soybeans and are also suited to small grains, grasses, and most legumes. In places alfalfa is hard to establish, and the stands die out early because of the excess moisture and damage as the result of frost heaving. The soils are suitable for development as wildlife habitat. Because of their clayey subsoil, which limits the growth of roots and the movement of air and water, they are not well suited to trees. The principal management needs are draining the soils and maintaining good tilth, the content of organic matter, and the supply of plant nutrients.

Crop residue should be well managed, and cover crops and green-manure crops should be grown to help to maintain good tilth and the content of organic matter. Surface drainage is generally needed. Land grading is a good means of insuring uniform surface drainage in some fields. Internal drainage is difficult; tile drains do not function well, because of the slow permeability of the subsoil. Terraces are needed in some areas where the slopes are long and are steeper than 2 percent.

A suitable cropping system is 3 years of row crops and 1 year each of a small grain and meadow. A fall and winter cover crop, turned under for green manure, may be substituted, however, for the meadow crop. Where the cropping system consists largely of row crops, tillage can be kept to a minimum to help maintain good tilth. Where less intensive management is practiced, a larger part of the cropping system should consist of meadow.

CAPABILITY UNIT IIIe-6

This capability unit consists of deep, dark-colored, moderately well drained and somewhat poorly drained soils of the Adair, Clarinda, Grundy, Keswick, Ladoga, Lagonda, Pershing, Sharpsburg, and Shelby series. These soils are gently sloping to sloping and are on uplands. The gently sloping soils are moderately eroded, and the sloping ones are slightly or moderately eroded.

These soils are moderately fertile and are generally easy to cultivate. Their available moisture capacity is moderate to high, and they have moderately slow to slow permeability. The content of organic matter is moderate in the moderately eroded soils and high in the soils that are not eroded or that are only slightly eroded. Further erosion is a hazard unless the soils are properly managed.

The soils of this unit are suited to the crops commonly grown in the county and are used mainly for corn, soybeans, oats, wheat, alfalfa, and grasses. Alfalfa grown on the Grundy, Lagonda, and Clarinda soils is generally damaged by severe heaving caused by frost action, and it is also damaged in some areas of the other soils. Only the Keswick, Ladoga, and Pershing soils are suited to trees. All of the soils are suitable for development of wildlife habitat. The major management needs are controlling erosion and increasing the content of organic matter, maintaining the supply of plant nutrients, and maintaining good soil tilth.

Managing crop residue well and growing meadow crops, cover crops, and crops for green manure help to protect these soils from erosion, and they increase the content of organic matter and improve soil tilth. Runoff and erosion can be controlled by practicing stripcropping and constructing terraces and waterways.

If practices that control erosion are not used, it is well to use a cropping system made up mostly of close-growing crops and to limit the number of row crops grown. A suitable cropping system is 1 year each of a row crop and a small grain and 3 years of meadow. If intensive management is used that includes terracing, constructing waterways, and farming on the contour, row crops can safely make up a greater part of the cropping system.

CAPABILITY UNIT IIIw-1

This capability unit consists of areas of Alluvial land and of a Nodaway soil. These soils are deep but have restricted drainage or are subject to frequent overflow. Alluvial land is generally poorly drained or somewhat poorly drained and has a seasonally high water table. The Nodaway soil is subject to frequent damaging flooding that generally results in an estimated loss of 20 to 50 percent of the crop.

Natural fertility is moderate to high, and these soils are easy to cultivate and have moderate to high available moisture capacity. In most places permeability is slow in the areas of Alluvial land and moderate in the Nodaway soil. The content of organic matter is medium to low.

The soils of this unit are suited to corn, soybeans, oats, wheat, grasses, and legumes. They are also suited to trees and can be developed as wildlife habitat. The major management needs are improving drainage and protecting the soils from flooding.

Green-manure crops and crop residue can be used to improve tilth and to help maintain the content of organic matter. Surface drainage is needed in many areas of Alluvial land, and tile drains can also be satisfactorily used to improve internal drainage in some places. The hazard of flooding is difficult to overcome in the Nodaway soil, but improving the stream channel and installing dikes or levees may be helpful in some areas. This hazard will not be completely overcome, however, until measures are taken to check runoff from the uplands in the watershed.

Unless adequate drainage is provided, wetness may be detrimental to alfalfa, bromegrass, and similar crops grown on these soils. Also, row crops can be damaged early in spring by flooding or excess water. Some of the areas are better used for pasture than for field crops. Row crops can be grown most of the time, however, if practices are used that improve tilth and increase the content of organic matter.

CAPABILITY UNIT IIIw-14

Only one soil, Wabash silty clay, is in this capability unit. It is a deep, nearly level, dark-colored, poorly drained soil of the bottom lands.

This soil is fairly fertile, but it is hard to cultivate and is difficult to work to a good seedbed. It holds a large amount of water, but only part of this water is available to plants. Nevertheless, the available moisture capacity is moderate to high. Surface runoff and permeability are both very slow. The content of organic matter is generally high.

This soil is plastic when wet and becomes hard and cracks when dry. Therefore, it can be cultivated only within a narrow range of moisture content. Deep plowing in fall is desirable because weathering breaks down the clods before spring, and preparing the seedbed is then much easier. Surface ditches are needed to provide drainage. Tile drains do not function properly, because water moves slowly through this soil. Land grading is an efficient way of providing uniform drainage.

If adequate drainage is provided, this soil is suited to soybeans, small grains, most grasses, and some legumes. It is not well suited to corn, bromegrass, alfalfa, other legumes, and trees, and it is poorly suited to development for wildlife habitat. The major management needs are improving drainage and maintaining good tilth and the supply of plant nutrients.

Crop residue should be returned to this soil, but winter cover crops are difficult to establish and are not especially effective for adding organic matter. If adequate drainage is provided, row crops can be grown most of the time. Some green-manure crops or meadow crops are needed, however, to improve tilth and to maintain the content of organic matter.

CAPABILITY UNIT IVe-6

This capability unit consists of deep, moderately well drained and somewhat poorly drained soils of the Adair, Clarinda, Gara, Grundy, Keswick, Ladoga, Lagonda, Pershing, Sharpsburg, and Shelby series. These soils are on uplands and are sloping or strongly sloping. The sloping soils are severely eroded, and the strongly sloping ones are moderately eroded.

Though these soils are fairly easy to cultivate, they require protection if they are cultivated. They have moderate natural fertility, moderate to high available moisture capacity, and moderately slow to slow permeability. The content of organic matter is low in the severely eroded soils, but it is medium to high in the moderately eroded ones. The soils are susceptible to further erosion unless they are properly managed.

The soils of this unit are not well suited to row crops but can be used for corn and soybeans if they are properly managed. To some extent, they are used for oats and wheat, and they are well suited to all the grasses and legumes commonly grown in the county. The Gara, Keswick, Ladoga, and Pershing soils are suitable for trees, and all the soils of this unit are suited to development for wildlife habitat. The major management needs are controlling erosion and maintaining the content of organic matter, the supply of plant nutrients, and good soil tilth.

If grasses and legumes are grown on these soils, soil losses are held to a minimum, the content of organic matter is increased, and tilth is improved. In most places the soils are suitable for terraces and waterways. Corn, soybeans, and other row crops can be safely grown where terraces and waterways have been constructed. In areas that are terraced, a suitable cropping system consists of 1 year each of a row crop and a small grain and 2 years of meadow crops.

CAPABILITY UNIT VIe-6

Areas of Terrace escarpments and of deep, moderately well drained, strongly sloping to steep soils of the Gara, Keswick, and Shelby series make up this capability unit. These soils are on uplands. The strongly sloping soils are moderately or severely eroded, and the steep soils are slightly or moderately eroded.

The soils of this unit have moderate to high natural fertility. The content of organic matter ranges from low in the severely eroded soils to high in the slightly eroded ones. The available moisture capacity is moderate to high, and permeability is moderately slow. All the soils of this unit are subject to further erosion if protective cover is not maintained.

Because of their steep slopes and the hazard of erosion, these soils are generally unsuitable for row crops, but they are suited to all the grasses and legumes commonly grown in the county. The Gara and Keswick soils, and the moderately eroded and severely eroded Shelby soils, are suited to trees. All the soils are well suited to the development of wildlife habitat. Control of erosion is the major management need.

These soils are too steep for terracing. Small grains may be safely grown occasionally, but row crops can be safely grown only very rarely, as when a pasture is renovated, perhaps once every 8 to 10 years. All tillage should be on the contour to help control erosion.

Most areas of these soils are in permanent vegetation and are used for pasture or woodlots. In the pastures a poor cover of grass can be improved by complete renovation or by improving the present stand. Gullied areas can be smoothed, fertilized, and seeded to a permanent cover of plants. Black walnut or a suitable species of pine can be used to replant woodlots where the stand is thin. The brushy areas can be converted to a more productive use by clearing and seeding to adapted grasses and legumes, or by planting to trees.

CAPABILITY UNIT VIIe-6

Deep, moderately well drained, very steep Gara and Shelby soils of the uplands are in this capability unit. The Shelby soil is not eroded or is only slightly eroded, but some areas of the Gara soils are severely eroded.

Natural fertility is moderate, and these soils have moderate available moisture capacity and moderate permeability. The content of organic matter ranges from low in the severely eroded Gara soils to high in the Shelby soil. The soils are subject to severe erosion if a protective cover is not maintained.

The soils of this unit are not suitable for cultivated crops and are generally too steep to be crossed by ordinary farm machinery. They can be used for grasses and legumes commonly grown in the county and are generally suitable for trees. The soils are well suited to development for wildlife habitat. Control of erosion is the major management need.

In many places the uneroded soils are covered by a stand of native hardwoods that need protection from fire and grazing. The woodlots can be made more productive by practicing good woodland management. Suitable trees can be planted in the open areas or on slopes where the soils are eroded. Where these soils are to be pastured, the gullied

areas can be smoothed and seeded to suitable grasses and legumes. The Shelby soil is already primarily in bluegrass.

Predicted yields

Table 2 gives the predicted average acre yields of crops commonly grown in Worth County. In columns A are yields to be expected under ordinary management. In columns B are yields to be expected under the high level of management practiced by some farmers in the county. Because response to management varies in different soils as a result of differences in natural fertility and in other properties of the soils that control response to management, comparing the yields in columns A with those in columns B will show the response to be expected on a given soil under improved management. The figures given are estimates of the average yield obtained over a period of approximately 10 years. They include some extremely high yields obtained in favorable seasons and some low yields obtained in years when drought, hail, or flooding damaged the crop.

Under the kind of management used to obtain the yields shown in columns A, a planned cropping sequence is generally followed. Some practices that help to control erosion and that conserve water are used, but those practices are not adequate to hold losses of soil material to a minimum. For some crops, lime and fertilizer are applied, but the amounts are smaller than the amounts needed, as indicated by the results of soil tests. Crop residue is generally returned to the soils, and wet areas are drained, though the drainage system is generally inadequate. The rate of planting is too low for high yields of some crops to be expected.

To obtain the yields of field crops shown in columns B, the following management practices are used:

1. A suitable cropping system is selected, based on the capabilities of the soils and on the kind of management practiced.
2. The soils are tilled on the contour, and terraces, waterways, and similar structures are used to supplement the cropping system and to help to control erosion and conserve water.
3. Lime and fertilizer are applied according to the needs indicated by the results of soil tests and the kind of crop to be grown.
4. Crop residue is used as a cover to protect the soils from erosion, and it is then returned to the soils.
5. Crops are planted at an appropriate time.
6. An adequate drainage system is installed so that excess surface water can be removed from wet areas.
7. Weeds are controlled through tillage, crop rotation, or spraying.
8. Crops are harvested at the proper time.
9. Adapted, high-yielding varieties of crops are planted, and the rate of planting is suitable.
10. Where alfalfa is grown for hay, high-yielding varieties are planted and the alfalfa is cut three times during the growing season. If the field is to remain in meadow the following year, the alfalfa is not cut or grazed from early in September until late in October.[6]

[6] Generally, the feed value of 3 tons of good alfalfa hay is equal to that of 80 bushels of corn.

Predicted yields of pasture are shown only for improved pasture, because only certain practices are generally used when a permanent pasture is to be seeded. The estimated yields given for pasture are mainly for a grass-legume mixture, such as a mixture of bromegrass and ladino clover, but the pasture on very steep soils consists mostly of bluegrass. Following are practices used to obtain the yields of pasture shown in columns B:

1. Lime and fertilizer are applied according to the needs indicated by the results of soil tests.
2. A mixture of adapted grasses and legumes is seeded.
3. Brush and weeds are controlled.
4. Established pastures are topdressed so that high yields of forage will be maintained.
5. Cattle are moved periodically between at least two different pastures, though a complete rotational system of grazing is seldom used. If a complete rotational system of grazing were used, the yields of improved pasture on some soils could be increased by as much as 20 to 30 percent, but this system normally would require five to seven pasture fields. Each segment would have to be used intensively but for only a short time (preferably less than 2 weeks) and then rested for 1 month.

Woodland Uses of the Soils

At the time Worth County was settled, nearly one-third of the acreage was in forest (fig. 6). The rest was covered by prairie vegetation consisting of native tall grasses and occasional scattered, brushy plants. The trees in the original forests grew in continuous belts that skirted the streams, and in both large and small groves on uplands adjacent to flood plains of the West, Middle, and East Forks of Grand River. The trees on the flood plains were larger and grew in a denser stand than those on the uplands. Oak and hickory were predominant on the uplands, and elm, cottonwood, and walnut grew on the bottom lands. Some areas of prairie were partly covered with prairie crab apple and hawthorn, and the same kinds of trees were especially abundant along the borders of the prairie.

Large tracts of dense timber are no longer common in this county. Less than 10 percent of the county is now wooded, and income from the sale of wood products makes up only a minor part of the total farm income. In 1959 only 3,150 acres was used primarily as woodland, according to figures of the U.S. Bureau of the Census. The rest of the wooded acreage is grazed and is not an important source of wood products. Throughout the county the timber has been cut over, and the present stands consist mostly of young trees that are poorly managed. About 85 percent of the acreage remaining in timber consists of steep Gara soils and of other Gara soils in narrow borders along streams. Small, scattered areas of Ladoga, Pershing, and Keswick soils on uplands are still in trees, as are areas of Nodaway and other soils on bottom lands.

Suitability for Woodland Planting.—Soils vary in their suitability for trees. In general, the deep, well drained and moderately well drained soils that have medium to high natural fertility are the most suitable. Most of the soils that are suited to trees, however, are also well suited to field crops. Many of them have been cleared and used for

TABLE 2.—*Predicted average acre yields of the principal crops under two levels of management*

[Yields in columns A are those to be expected under ordinary management, and yields in columns B are those to be expected under improved management. Absence of a yield figure indicates that the crop is not commonly grown at the management level indicated]

Soil	Corn		Soybeans		Oats		Alfalfa hay		Pasture
	A	B	A	B	A	B	A	B	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Cow-acre-days* [1]
Adair silt loam variant and Adair loam, 2 to 5 percent slopes, moderately eroded	40	60	22	26	18	26	2.5	3.5	170
Adair and Shelby loams, 5 to 9 percent slopes	40	60	22	26	20	30	3.0	4.0	170
Adair and Shelby loams, 5 to 9 percent slopes, moderately eroded	30	60	20	24	18	26	2.5	3.5	160
Adair and Shelby soils, 5 to 9 percent slopes, severely eroded	25	55	15	20	15	20	1.8	3.0	130
Alluvial land	40	60	20	30	25	35	2.0	3.0	165
Edina silt loam, benches, 0 to 3 percent slopes	35	65	18	24	30	40	3.0	4.0	135
Gara loam, 9 to 14 percent slopes, moderately eroded	35	55	16	22	26	34	2.0	3.5	120
Gara loam, 14 to 20 percent slopes, moderately eroded	----	----	----	----	----	----	2.0	3.0	95
Gara loam, 20 to 35 percent slopes	----	----	----	----	----	----	----	----	90
Gara soils, 20 to 35 percent slopes, severely eroded	----	----	----	----	----	----	----	----	60
Grundy silt loam, 2 to 5 percent slopes	45	70	24	30	40	50	2.5	3.5	160
Grundy silt loam, 2 to 5 percent slopes, moderately eroded	40	65	22	28	35	40	2.0	3.0	140
Grundy silt loam, benches, 0 to 2 percent slopes	40	70	24	30	40	50	2.0	3.0	160
Grundy silt loam, benches, 2 to 5 percent slopes	45	70	24	30	40	50	2.5	3.5	160
Grundy silt loam, benches, 5 to 9 percent slopes, moderately eroded	35	60	18	24	36	40	1.8	2.8	120
Kennebec silt loam	65	95	25	35	50	60	3.5	4.5	180
Keswick loam, 5 to 9 percent slopes	40	60	20	25	20	30	3.0	4.0	150
Keswick loam, 5 to 9 percent slopes, moderately eroded	35	50	18	22	18	26	2.5	3.5	140
Keswick soils, 5 to 9 percent slopes, severely eroded	25	45	15	20	15	24	1.5	3.0	110
Keswick loam, valleys, 5 to 9 percent slopes, moderately eroded	25	50	16	22	15	25	1.8	2.4	125
Keswick soils, valleys, 5 to 9 percent slopes, severely eroded	----	----	----	----	----	----	1.2	1.8	80
Keswick loam, valleys, 9 to 14 percent slopes, moderately eroded	----	----	----	----	----	----	1.5	2.0	100
Keswick soils, valleys, 9 to 14 percent slopes, severely eroded	----	----	----	----	----	----	1.0	1.5	85
Ladoga silt loam, 2 to 5 percent slopes	40	60	20	26	20	35	2.5	3.5	160
Ladoga silt loam, 5 to 9 percent slopes, moderately eroded	30	50	18	22	16	30	2.0	3.0	140
Ladoga silt loam, 9 to 14 percent slopes, moderately eroded	30	50	18	22	15	25	2.0	3.0	130
Ladoga silt loam, benches, 2 to 5 percent slopes	40	60	20	26	20	35	2.5	3.5	160
Ladoga silt loam, benches, 5 to 9 percent slopes, moderately eroded	35	60	18	22	16	30	2.0	3.0	150
Lagonda and Clarinda soils, 5 to 11 percent slopes	35	65	20	26	20	35	2.0	2.5	100
Lagonda and Clarinda soils, 5 to 11 percent slopes, moderately eroded	30	55	18	24	16	30	1.8	2.2	80
Lagonda and Clarinda soils, 5 to 11 percent slopes, severely eroded	25	35	14	18	10	20	1.2	1.6	50
Nevin silt loam	55	85	25	35	45	55	3.0	4.0	180
Nodaway silt loam	65	90	24	32	45	55	3.5	4.5	180
Nodaway silt loam, overflow	50	70	20	30	20	30	3.0	4.0	170
Olmitz loam, 2 to 5 percent slopes	60	90	25	35	50	60	3.0	4.0	175
Olmitz-Kennebec complex, 0 to 5 percent slopes	60	90	20	30	42	55	3.0	4.0	175
Pershing silt loam, 2 to 5 percent slopes	35	60	20	25	30	40	2.0	2.5	150
Pershing silt loam, 2 to 5 percent slopes, moderately eroded	25	50	18	24	26	34	1.8	2.4	135
Pershing silt loam, 5 to 9 percent slopes	30	55	18	24	28	36	2.0	2.5	140
Pershing silt loam, 5 to 9 percent slopes, moderately eroded	25	50	16	22	24	32	1.8	2.4	125
Pershing silt loam, benches, 2 to 5 percent slopes	35	60	20	25	30	40	2.0	2.5	150
Pershing silt loam, benches, 2 to 5 percent slopes, moderately eroded	25	50	18	24	26	34	1.8	2.4	135
Pershing silt loam, benches, 5 to 9 percent slopes, moderately eroded	25	50	16	22	24	30	1.8	2.4	125
Pershing and Grundy soils, benches, 5 to 9 percent slopes, severely eroded	20	35	14	20	18	26	1.5	2.0	95
Sharpsburg silt loam, 2 to 5 percent slopes	45	70	25	30	35	45	3.0	4.0	175
Sharpsburg silt loam, 2 to 5 percent slopes, moderately eroded	40	65	25	30	30	40	2.5	3.5	170
Sharpsburg silt loam, 5 to 9 percent slopes	40	65	24	28	35	45	3.0	4.0	175
Sharpsburg silt loam, 5 to 9 percent slopes, moderately eroded	35	60	22	28	30	40	2.5	3.5	165
Sharpsburg soils, 5 to 9 percent slopes, severely eroded	30	55	18	25	22	34	2.0	3.0	150
Sharpsburg silt loam, benches, 3 to 8 percent slopes	40	65	25	30	30	40	3.0	4.0	170
Shelby loam, 9 to 14 percent slopes	35	60	20	24	32	38	2.5	3.5	150
Shelby loam, 9 to 14 percent slopes, moderately eroded	30	50	18	22	26	34	2.0	3.0	130
Shelby loam, 14 to 20 percent slopes	----	----	----	----	----	----	2.0	3.0	120
Shelby loam, 14 to 20 percent slopes, moderately eroded	----	----	----	----	----	----	1.5	3.0	100
Shelby and Gara soils, 9 to 20 percent slopes, severely eroded	----	----	----	----	----	----	1.5	2.5	80
Shelby loam, 20 to 30 percent slopes	----	----	----	----	----	----	----	----	90
Terrace escarpments	----	----	----	----	----	----	2.0	2.5	100
Wabash silty clay	35	55	20	25	20	25	1.5	2.0	130
Wabash silty clay loam	40	65	22	30	25	35	2.0	3.0	160

[1] Cow-acre-days is a term used to express the carrying capacity of pasture. It is the number of animal units carried per acre multiplied by the number of days the pasture is grazed during a single grazing season without injury to the sod. An acre of pasture that provides 30 days of grazing for two cows has a carrying capacity of 60 cow-acre-days.

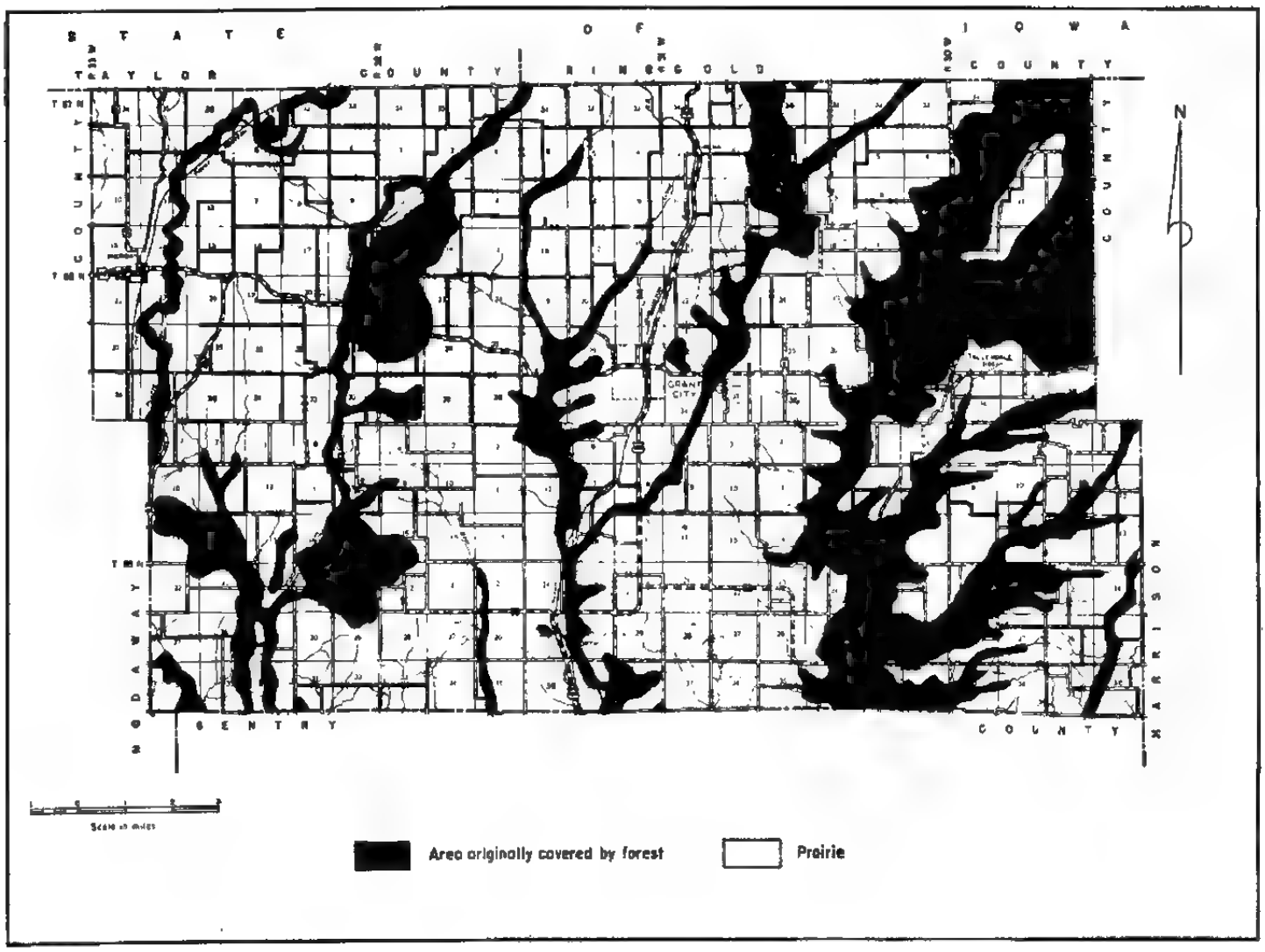

Figure 6.—Native vegetation in Worth County.

field crops. For example, most areas of Ladoga, Pershing, Keswick, and Nodaway soils have been cleared and used for crops because those soils are more in demand for grain or pasture than for trees. Nevertheless, returns from some well-managed tracts of woodland on those soils compare favorably with returns from pasture. The severely eroded areas should be given special consideration for trees.

Such soils as the Adair, Grundy, Sharpsburg, and Shelby are generally more suitable for grain crops, meadow, and pasture than for trees, but the steep and severely eroded areas of Shelby soils are suitable for use as woodland. Terrace escarpments and the Gara, Keswick, and Shelby soils of capability units VIe–6 and VIIe–6 are not suitable for cultivation but are suitable for trees or pasture. Those soils should be considered when trees are to be planted.

Trees require different plant nutrients than do the common field crops. Poor soils for crops are not necessarily good ones for trees, however, though trees may give a fair return for the amount of labor invested. Trees generally require soils that are strongly acid or very strongly acid, and such soils are generally too acid for most row crops.

Planting of Trees.—Table 3 gives the estimated site class (*12*) [7] for the soils of five series and suggests kinds of trees suitable for planting on several of the soils. It also names the least desirable species, acceptable species, and species to favor in the existing stands. Trees have been planted in only a few small areas in this county, mainly by private landowners. These plantings were established mostly for windbreaks, Christmas trees, wildlife habitat, or recreational purposes. On most of the soils, the growth of trees has been encouraging.

The windbreaks that have been planted consist of trees or shrubs grown in narrow belts to control the deposition of snow, to prevent wind damage to farmsteads, and to provide shelter for livestock. For some of the early windbreak plantings, Osage-orange, redcedar, and black locust were used. Many hedgerows of Osage-orange are still maintained, and in those the wood is regularly harvested for

[7] Italic numbers in parentheses refer to Literature Cited, p. 48.

TABLE 3.—*Estimated site class, species suggested for planting, species to favor, acceptable species, and least desirable species in existing stands on the soils of five series*

[Dashed lines indicate trees are not commonly planted on the soil]

Soil series	Site class (estimated) [1]	Species suggested for planting [2]	Existing stands		
			Species to favor	Acceptable species	Least desirable species
Gara	3	Walnut (on the lower slopes.)	Walnut, white oak, red oak.	Ash [3]	Elm, hackberry, hickory, pin oak.
Keswick	1 to 2	----------	White oak, red oak	Redcedar,[3] cherry	Hickory, honeylocust, elm, shingle oak.
Ladoga	2	----------	White oak, red oak	----------	Elm, honeylocust, hickory.
Nodaway	4	Walnut	Walnut, white oak, red oak, soft maple.	Cottonwood,[3] ash [3]	Boxelder, elm, hackberry.
Pershing	2	----------	White oak	Cherry [4]	Hickory, elm, honeylocust, hawthorn.

[1] Number of 16-foot logs having a maximum diameter of 8 inches that can be produced by a tree. The trees in site class 1 are capable of producing a maximum average annual growth of 90 board feet per acre in an unmanaged stand; the trees in site class 2 are capable of producing a maximum average annual growth of 150 board feet in an unmanaged stand; the trees in site class 3 are capable of producing a maximum average annual growth of 210 board feet in an unmanaged stand; and those in class 4 are capable of producing a maximum average annual growth of 275 board feet in an unmanaged stand (*12*).

[2] Does not include trees planted for windbreaks or Christmas trees.

[3] Could be considered for planting.

[4] Might be considered as a species to favor.

posts. More recently, Scotch pine, eastern white pine, Chinese elm, and Norway spruce have been used for windbreak planting, and in those plantings multiflora rose is generally included. Other species acceptable for windbreaks are jack pine, redcedar, pin oak, and green ash.

Scotch pine and jack pine are both planted for Christmas trees. For those trees a protected site appears to be the best. The trees are sheared when they are about 3 feet high so that they will attain a uniform shape and have uniformly dense foliage. They are harvested 4 to 6 years after they are planted.

The soils of the county have potential for forestry plantations and for plantations that would help to control erosion. Those that were formerly cultivated are poorly suited to hardwoods, but black walnut is suitable for seeding in open wooded areas of deep, fertile soils. Pines could be considered where fields that were formerly cultivated or that are eroded are to be converted to woodland.

WOODLAND MANAGEMENT.—The early settlers did not try to manage the wooded areas but sought them only as a source of fuel, material for fences, and material for houses and barns. They harvested the best trees and left the least desirable ones. Later, overgrazing and fire caused even greater damage than cutting. As a result, the present wooded areas are unproductive, though some of the present stands could be improved.

All of the native stands consist of a hardwood type of forest. For all the timber types, however, management suitable for even-aged stands appears to be the best. Overstocked, immature stands can be thinned and the best trees favored. Harvest cutting should be done in a way that will assure the development of thrifty even-aged stands of desirable trees. Occasional cull trees may be left to provide more favorable habitat for wildlife.

The wooded areas should be protected from fire and grazing. Fire destroys the small trees, burns the litter and humus from the surface of the soils, and upsets the biotic soil conditions essential to the growth of healthy trees. It also scars the larger trees, and it leaves exposed wood that can be damaged by insects and decay. Intensive grazing destroys the future crops of trees, and trampling by livestock damages the surface soil where plant roots obtain nourishment. Trampling also compacts the soils so that the ability to absorb water is reduced.

The hardwoods in some wooded tracts are of such poor quality that converting the areas to some other type of timber use might be desirable. Plantings made for windbreaks or Christmas trees are generally profitable in those areas. Clearing the land and converting it to grazing use is also a possibility where establishing pasture is feasible.

Wildlife [3]

When Worth County was first settled, elk, deer, prairie chicken, wild turkey, woodcock, timber wolf, raccoon, opossum, gray squirrel, nongame birds, rodents, and other lesser mammals inhabited the area, and an occasional bear roamed the uplands. Beaver, mink, muskrat, and weasel lived along the streams. The rivers contained channel, flathead, and bullhead catfish, buffalofish, drum, and black perch.

As the settlers moved in, they cleared the trees and plowed the prairie grassland, and thus changed the habitat to one of short grasses, row crops, and borderland timber. Changing the habitat, and hunting game intensively for food and market, caused the prairie chicken, deer, elk, bear, woodcock, wolf, and beaver to disappear. Quail and rabbit moved into edges of the cultivated areas, and fox squirrel replaced the gray squirrel. Fox and coyote then became the major predators and are still prevalent in the county. A few pheasant now have their habitat along the northern border of the county. Beaver and deer are again plentiful, largely as the result of restocking and management programs established in cooperation with the Missouri Conservation Commission.

Straightening the channels of the Platte River and of the West and Middle Forks of Grand River destroyed

[3] By THOMAS L. DAVIS, field service agent, Missouri Conservation Commission.

many of the holes that were once inhabited by catfish, drum, and buffalofish. The channel of the East Fork Grand River has not been straightened, however, and that river now provides the best river fishing in the county. It is inhabitated by native catfish, buffalofish, drum, and black perch, and it also contains European carp. Other fishing areas are provided by several hundred ponds and small lakes that have been constructed in the county during the past 20 years. These are stocked with channel catfish, bullhead, bass, bluegill, perch, and crappie.

Soil-Plant-Animal Relationships.—Showing a direct relationship between the soils and plants and between the plants and animals of Worth County is difficult because many plants grow on more than one kind of soil, and, in turn, animals eat many kinds of plants. Table 4, however, gives the names of some of the principal kinds of wildlife in the county, plants suitable for food for each kind, and areas used as habitat.

Wildlife Management.—During the past 25 years, an attempt has been made to manage wildlife in the county. The ponds and lakes have been stocked with bass, bluegill, and channel catfish. Deer and beaver have been reintroduced and have thrived and become important both for economic and recreational purposes. Special attention has been given to improving the habitat for wildlife in the watershed of the Platte River. Plantings for wildlife have been established, and rivers and ponds have been stocked with fish.

Current farm conservation plans include the development of wildlife habitats in suitable areas of the farm. The Missouri Conservation Commission and the Soil Conservation Service have provided technical assistance. The Missouri Conservation Commission has also supplied farmers with seeds and plants that can be used to improve the habitat for wildlife and has provided fish for stocking the streams and ponds. It has also given assistance in establishing a 20-acre fishing lake that is surrounded by a small refuge area. The refuge area supports some upland game birds and animals but mainly provides a resting place for migrating waterfowl.

Table 4.—*Plants suitable for food, and areas used as habitat for specified kinds of wildlife*

Kind of wildlife	Plants suitable for food	Areas used as habitat
Deer	Corn, alfalfa, wheat, oak, coralberry, sumac.	Areas near cover in soil association 3.
Pheasant	Ragweed, soybeans, foxtail, smartweed, false buckwheat, sumac, corn, wild beans.	Soil associations 1 and 2.
Quail	Korean lespedeza, corn, grain sorghum, soybeans, foxtail, ragweed, beggartick, wild beans, sumac, tick trefoil, oak.	Nearly all areas of the county.
Rabbit	Korean lespedeza, corn, soybeans, wheat, ragweed, blackberries, clover, orchardgrass, timothy, sericea lespedeza, multiflora rose.	Nearly all areas of the county where food and cover are available.
Squirrel	Oak, hickory, walnut, Osage-orange, mulberry, maple, corn.	Mainly soil association 3.

As farmers seed more of their land to grass, and as the farms become larger and require more machinery, areas that provide food and cover for wildlife will become more scarce. For this reason, members of both the Worth County Soil and Water Conservation District and the Missouri Conservation Commission are intensifying their programs to improve the habitat for small game birds and game animals in the county.

Engineering Uses of the Soils

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, building foundations, facilities for storing water, erosion control structures, drainage systems, and systems for disposing of sewage. Among the most important of these soil properties are permeability, drainage, texture, plasticity, and depth to hard rock and to the water table.

The information in this soil survey can be used to—

1. Make soil and land use studies that will aid in selecting and developing sites for industries, businesses, residences, and recreational areas.
2. Make preliminary estimates of the engineering properties of soils for use in planning structures for drainage and irrigation and in planning dams and other structures to be used for conserving water and soil.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting locations for highways, airports, pipelines, cables, and sewage disposal fields and in planning detailed surveys of the soils at the selected locations.
4. Correlate pavement performance with types of soil and thus develop information that will be useful in designing and maintaining the pavement.
5. Determine the suitability for cross-country movement of vehicles and construction equipment.
6. Supplement the information obtained from other published maps, reports, and aerial photographs for the purpose of making soil maps and reports that can be readily used by engineers.
7. Develop preliminary estimates for other types of construction in the county.

Used with the soil map to identify the soils, the engineering interpretations in this section are useful for many purposes. It should be emphasized, however, that these interpretations may not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads or where the excavations are deeper than the depth of the layers here reported. Nevertheless, even in such situations, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that can be expected.

Information of value in planning engineering work is given throughout the text, especially in the section "Descriptions of the Soils" and in the section "Geology" where glacial till, important to engineering work, is discussed. Some terms used by soil scientists may be unfamiliar to engineers, and many words have special meaning in soil science. These and other special terms are defined in the Glossary at the back of this soil survey.

Much of the information in this section is in tables.

Table 5 gives engineering test data obtained when the samples of selected soil series were tested. Table 6 gives estimates of the properties of the soils, and table 7 provides engineering interpretations of these properties.

Engineering classification systems

Agricultural scientists of the U.S. Department of Agriculture classify soils according to texture. In some ways this system of naming textural classes is comparable to the two systems used by engineers for classifying soils; that is, the system of the American Association of State Highway Officials (AASHO) (*2*) and the Unified system.

Most highway engineers classify soil materials in accordance with the classification developed by the American Association of State Highway Officials. In this system soil materials are classified in seven principal groups. The groups range from A-1, consisting of gravelly soils of high bearing capacity, to A-7, consisting of clayey soils that have low strength when wet. Under this system the soils of Worth County range from A-4 through A-7 (see table 6). Within each group, the relative engineering value of the soil material is indicated by a group index number. Group index numbers range from zero for the best material to 20 for the poorest. In this soil survey, group index numbers are assigned only to soils on which tests have been performed. They are shown in parentheses after the soil group symbols in the AASHO classifications in table 5.

Some engineers prefer to use the Unified soil classification system (*19*). In the Unified system, soil materials are identified as coarse grained, eight classes; fine grained, six classes; and highly organic. Within these classes two letters, for example, ML, are used to indicate the kind of soil material and to designate each soil group. The letters used to indicate kinds of soil material are G, S, M, and C, which stand for gravel, sand, silt, and clay, respectively. The letter O is used to indicate silt or clay that has a high content of organic matter.

The letters W, P, L, and H stand for well graded, poorly graded, low liquid limit, and high liquid limit, respectively. Where the symbols of two soil separates are given, for example SM for sand and silt, the first letter indicates the dominant soil separate. Soils on the borderline between two classifications are given a joint classification, for example, ML-CL. The last column of table 5 gives the Unified engineering classification of the soils tested.

Soil test data and engineering properties of the soils

The data given in table 5 show the results of tests made by the Missouri State Highway Commission under a cooperative agreement with the Bureau of Public Roads and the Soil Conservation Service. Results of the tests help to evaluate the soils for engineering purposes. The tests were made in accordance with standard procedures. The samples tested are from the B and C horizons and generally were taken at some depth between 13 and 60 inches.

The engineering soil classifications given in table 5 are based on data obtained by mechanical analysis and on the results made to determine the liquid limit and plasticity index of the soils tested. Mechanical analyses were made by combined sieve and hydrometer methods.

Table 5 gives compaction (moisture-density data) for the tested soils. Moisture-density data are important in earthwork, for as a rule, optimum stability is obtained if the soil is compacted to about the maximum dry density when it is at approximately the optimum moisture content.

Tests for liquid limit and plastic limit measure the effects of water on the consistence of the soil material. As the moisture content of a clayey soil increases from a very dry state, the material changes from a semisolid to a plastic. As the moisture content is further increased, the material changes from a plastic to a liquid. The plastic limit is the moisture content at which the soil material passes from a semisolid to a plastic. The liquid limit is the moisture content at which the material passes from a plastic to a liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is in a plastic condition.

In table 6 the three columns under the heading "Classification" define the soil material as it is classified both by soil scientists and by engineers. The estimated range in percentages passing sieve Nos. 4, 10, and 200 reflects the normal range for a soil series, and most soils fall within the range given. The grain size of any soil varies considerably, however, and it should not be assumed that all samples of a specific soil will fall within the range shown.

Permeability of a soil, as used in this section of the soil survey, refers to the ability of the soil to transmit water and is given as inches per inch of soil depth. In table 6 the estimates of permeability are for the soil in place and were obtained by comparing the soil with soils of known permeability or by using the common range in permeability of soils of a given texture.

The available moisture capacity, expressed in inches of water per inch of soil depth, is the amount of water available to plants. This water is held in the range between field capacity of the soil and the permanent wilting point of common crops.

Reaction refers to the pH value of the soil. A notation of 7.0 indicates precise neutrality. Lower values indicate increasing acidity, and higher values indicate increasing alkalinity.

The shrink-swell potential is an indication of the volume change to be expected with a change in moisture content. The ratings given are "high," "moderate," and "low." They were estimated as the normal shrink-swell potential for given soil textures of the county.

Engineering interpretations of the soils

Table 7 indicates the suitability of the soils as sources of material affecting work on highways; names soil features that affect suitability for structures used in conservation engineering (as terraces, diversions, and grassed waterways); and gives factors that affect drainage practices that would make the soils more suitable for crops. In addition, it names soil features that affect suitability of the soils for septic tanks, and those factors, in turn, affect suitability for residential development. The data in this table are estimated. They are based on the engineering test data in table 5 and on observed performance of the soils in the field.

Soil Features Affecting Work on Highways.—Table 7 rates the soils as a source of topsoil. To obtain the ratings given, engineers determined the suitability of the surface layer as a source of topsoil because that layer contains the largest amount of organic matter. The ratings do not apply

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TABLE 5.—*Engineering test data*[1] *for*

Soil name and location	Parent material	Missouri report No.	Depth	Horizon	Moisture density[2]	
					Maximum dry density	Optimum moisture
		68/N	*Inches*		*Lb. per cu. ft.*	*Percent*
Adair loam: 350 ft. W. of the SW. corner of SW¼ sec. 31, T. 66 N., R. 30 W.	Glacial till.	20594	21–28	IIB21t	97	20
		20595	40–60	IIC	116	16
Gara loam:[3] 600 ft. S. of NE¼ sec. 29, T. 65 N., R. 30 W.	Glacial till.	20598	21–26	B2	106	19
		20599	42–50	C	116	14
Lagonda silt loam: NW. corner of SW¼ sec. 23, T. 65 N., R. 31 W.	Glacial till.	20596	20–24	B21t	100	21
		20597	42–50	B3g or IICg	104	20
Sharpsburg silt loam: 30 ft. E. of SW. corner of SE¼ SW¼ sec. 26, T. 66 N., R. 31 W.	Loess.	20602	13–20	B21t	100	20
		20603	38–60	C	104	19
Shelby loam: NE. corner of NW¼ sec. 27, T. 65 N., R. 32 W.	Glacial till.	20600	20–25	B21t	113	16
		20601	46–60	C	114	15
Wabash silty clay loam: SE¼ SW¼ sec. 8, T. 65 N., R. 31 W.	Alluvium.	20593	13–21	A13	93	23

[1] Tests performed by the Missouri State Highway Commission in accordance with standard procedures of the American Association of State Highway Officials (AASHO).

[2] Based on AASHO Designation T 99–57, Method C (*2*).

[3] Mechanical analyses according to AASHO Designation T 88–57 (*2*), except that the 0.002 millimeter value is based on the extrapolation of the hydrometer analysis curve beyond the 4-hour reading (0.003+ millimeter). Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all

to soils that are severely eroded. The surface layer of most of the soils that are not eroded, however, is suitable for use in topdressing cuts, fills, and the shoulders of roads, and it could also be used for topdressing gardens and lawns. A fair stand of grass can be established on undesirable soil material from the B and C horizons if that material is properly fertilized and is temporarily stabilized by mulching.

Suitability of the soils for highway subgrade material (see table 7) is based primarily on the classification of the soils in the AASHO system. To be given a rating of "good" for subgrade material, the soil material must be coarse textured. In general, soils that have a clayey texture (A–7) are the least desirable for highway subgrade. They are difficult to compact, excavate, and manage and are given a rating of "poor" or "very poor." In Worth County all the soils have a fine-textured surface layer or a high content of organic matter, and some soils have both. Therefore, none of the soils are given a rating of better than "fair" for subgrade. The Nodaway and Kennebec soils, which have been given a rating of "fair," are silty but are the most desirable for subgrade for highways. Their AASHO classification is A–4.

The soils were not rated as sources of sand and gravel that could be used in constructing highways, because this county has no significant sources of sand and gravel. Limestone is quarried, however, in several places along the East Fork Grand River and is crushed for use in the construction of highways.

Suitability for road fill is also not rated in table 7. Suitability for fill is based primarily on the compaction characteristics of a soil. Soils that have a silty surface layer generally have a narrow range of moisture content for effective compaction, and some soils have a high content of organic matter that also contributes to poor compaction. The soil material in the surface layer is generally given the lowest rating as fill material. Clayey material that has high plasticity, for example that in the subsoil of the Clarinda, Edina, Grundy, Lagonda, Pershing, and Sharpsburg soils, is considered fair as road fill. Clay loam and similar material that is typical in the subsoil of the Adair, Gara, Keswick, and Shelby soils are considered good for fill. In constructing a fill or in performing other work necessary in the construction of highways, landslips or landslides are generally not a hazard in this county, but they occasionally occur in areas of very steep Gara soils. In most places bedrock is deep enough that it is not reached when a road is constructed.

In table 7 the influence of soil features that affect the location of highways is estimated, and the estimates are based on the characteristics of the subsoil and substratum. In making these estimates, it was assumed that the surface layer had been removed in construction. Slope, a high water table, and flooding were all considered, as well as the characteristics of the subsoil and substratum.

soil samples taken from six soil profiles

Mechanical analysis [3]								Liquid limit	Plasticity index	Classification	
Percentage passing sieve—				Percentage smaller than—						AASHO [4]	Unified [5]
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
100	99	93	74	72	58	46	42	49	27	A-7-6(16)	CL.
100	99	93	70	62	46	36	32	44	30	A-7-6(16)	CL.
92	90	83	65	60	48	36	32	50	31	A-7-6(16)	CL.
100	99	93	74	68	54	42	37	50	34	A-7-6(18)	CL.
----------	100	99	95	88	68	46	38	60	38	A-7-6(20)	CH.
----------	100	97	86	79	63	50	42	59	40	A-7-6(20)	CH.
----------	----------	100	99	93	72	46	38	54	30	A-7-6(19)	CH.
----------	----------	100	99	93	70	42	35	54	33	A-7-6(19)	CH.
100	98	87	68	63	52	40	34	49	31	A-7-6(16)	CL.
100	97	89	69	64	53	38	32	46	30	A-7-6(16)	CL.
----------	----------	100	98	96	86	64	54	77	54	A-7-6(20)	CH.

the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soils.

[4] Based on AASHO Designation M 145-49 (*2*).

[5] Based on the Unified Soil Classification System (*19*).

[6] In the B2 horizon, 99 percent of the soil material passed a ¾-inch sieve and 100 percent passed a 1½-inch sieve.

CONSERVATION ENGINEERING.—Features that affect the suitability of the soils for reservoirs, embankments for ponds, and terraces and diversions are considered in table 7. Also considered are features that affect suitability for agricultural drainage. Features that affect the suitability of the soils for reservoirs for ponds are ones that affect the impounding of water in an undisturbed soil. Most of the soils on uplands in the county are well suited to use for reservoirs. The soils in upland drainageways are safe for impounding water if the fills are properly sealed to control seepage. The only areas not suitable are those where limestone bedrock crops out in a few places on the steep slopes along the East Fork Grand River and where the underlying glacial till contains a few large pockets of sand. All the soils of the county can be safely used for dikes, levees, or embankments for farm ponds if they are properly compacted and sealed so that seepage is controlled.

All the soils of the county are suitable for terraces and diversions, except those that have slopes of 12 percent or more. The Clarinda, Edina, Lagonda, and Pershing soils, however, have a clayey subsoil that limits the depth of the channel, though their slopes are favorable. On those soils establishing vegetation is difficult where the subsoil is exposed. In some places diversion terraces are used to protect the soils from eroding or to divert upland runoff from areas of bottom lands.

Features that affect the establishment, growth, and maintenance of a cover of plants are considered in planning and establishing waterways. The main limiting factors are steep slopes that are easily eroded, and the difficulty of establishing vegetation where the subsoil is exposed.

Needs both for surface drainage and subsurface drainage are considered in the column headed "Agricultural Drainage." Disposing of water from runoff is the major management need of the soils of bottom lands, and disposing of seepage on hillsides is the major management need of soils of the uplands. The need for drainage is greater in areas of Wabash soils and in areas of Alluvial land than in other soils of the county. Tile drains are used to intercept seepage in some soils of the uplands. Artificial drainage is not required for some soils.

Irrigation was not considered in table 7, because it is not practiced to any extent in this county. Reductions in yields caused by lack of rainfall are not great enough that developing an irrigation system is generally considered worth while. Also, areas suitable for deep wells that could be used as a source of irrigation water are scarce (see fig. 8, p. 47), and the rivers flow only intermittently. During dry seasons the rivers are not a dependable source of any appreciable amount of water. Facts about the supply of water in this county are given under the heading "Physiography, Drainage, and Water Supply" in the section "Additional Facts About the County."

TABLE 6.—*Estimated properties of the soils*

[Alluvial land (Au) and Terrace escarpments (Te) are too variable in characteristics for their properties to be estimated]

Soil series and map symbol	Depth from surface	Classification			Percentage passing sieve—			Permeability	Available moisture capacity	Reaction	Shrink-swell potential
		USDA texture	Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
	Inches							*Inches per hour*	*Inches per inch of soil depth*	*pH value*	
Adair (AaB2, AsC, AsC2, AsC3).	0–14	Silt loam or loam.	ML–CL	A–4	----	100	70–80	0.8–2.5	0.18–0.23	5.2–6.0	Low.
For properties of the Shelby soils in AsC, AsC2, and AsC3, refer to the Shelby series.	14–40	Gritty clay	CL	A–7–6	100	95–100	70–80	0.05–0.2	0.15–0.18	5.0–6.0	Moderate to high.
	40–60	Clay loam	CL	A–7–6 or A–6.	100	95–100	60–80	0.2–0.8	0.16–0.18	5.5–6.0	Moderate.
Clarinda.	0–9	Silt loam	ML–CL	A–4	100	95–100	85–95	0.8–2.5	0.18–0.23	6.0–6.5	Low.
	9–48	Clay	CH	A–7–6	100	95–100	75–95	<0.05	0.15–0.18	5.5–6.5	High.
Edina (EbA).	0–18	Silt loam	ML–CL	A–4	----	100	95–100	0.8–2.5	0.18–0.23	5.5–6.0	Low.
	18–32	Silty clay	CH	A–7–6	----	100	95–100	<0.05	0.15–0.18	5.0–5.5	High.
	32–48	Silty clay loam.	CL	A–7–6	----	100	95–100	0.2–0.8	0.19–0.21	5.5–6.5	Moderate to high.
Gara (GaD2, GaE2, GaF, GrF3).	0–12	Loam	ML–CL	A–4	100	95–100	60–75	0.8–2.5	0.14–0.18	5.0–7.0	Low.
	12–50	Clay loam	CL	A–7–6	100	95–100	60–75	0.2–0.8	0.16–0.18	4.8–6.5	Moderate to high.
Grundy (GsB, GsB2, GuA, GuB, GuC2).	0–11	Silt loam	ML–CL	A–4	----	100	95–100	0.8–2.5	0.18–0.23	6.0–7.0	Low.
	11–44	Silty clay	CH	A–7–6	----	100	95–100	<0.05	0.15–0.18	5.0–6.5	High.
	44–56	Silty clay loam.	CL	A–7–6	----	100	95–100	0.2–0.8	0.19–0.21	6.0–7.0	Moderate to high.
Kennebec (Kc).	0–56	Silt loam	ML–CL	A–4	----	100	75–95	0.8–2.5	0.18–0.23	6.0–7.2	Low.
Keswick (KeC, KeC2, KkC2, KkD2, KsC3, KvC3, KvD3).	0–9	Loam	ML–CL	A–4	100	95–100	60–70	0.8–2.5	0.14–0.18	4.5–6.5	Low.
	9–24	Silty clay	CH or CL.	A–7–6	100	95–100	75–90	0.1–<0.05	0.15–0.18	4.5–5.5	Moderate to high.
	24–56	Clay loam	CL	A–7–6	100	95–100	65–75	0.2–0.8	0.16–0.18	5.0–6.5	Moderate to high.
Ladoga (LaB, LaC2, LaD2, LbB, LbC2).	0–11	Silt loam	ML–CL	A–4	----	100	95–100	0.8–2.5	0.18–0.23	5.5–7.0	Low.
	11–54	Silty clay loam.	CL	A–7–6	----	100	95–100	0.2–0.8	0.19–0.21	4.5–5.5	Moderate to high.
Lagonda (LcC, LcC2, LcC3).	0–12	Silt loam	ML–CL	A–4	----	100	95–100	0.8–2.5	0.18–0.23	6.0–7.0	Low.
For properties of the Clarinda soils in these mapping units, refer to the Clarinda series.	12–20	Silty clay loam.	CL	A–7–6	----	100	90–100	0.2–0.8	0.19–0.21	5.5–6.5	Moderate to high.
	20–46	Silty clay or clay.	CH	A–7–6	100	95–100	80–95	<0.05	0.15–0.18	6.0–7.0	High.
Nevin (Ne).	0–13	Silt loam	ML–CL	A–4	----	100	85–95	0.8–2.5	0.18–0.23	6.0–6.5	Low.
	13–46	Silty clay loam.	CL	A–7–6	----	100	80–90	0.2–0.8	0.19–0.21	5.5–6.5	Moderate to high.
Nodaway (No, Nw).	0–60	Silt loam	ML–CL	A–4	----	100	70–90	0.8–2.5	0.18–0.23	6.0–7.0	Low.

TABLE 6.—*Estimated properties of the soils*—Continued

Soil series and map symbol	Depth from surface	Classification			Percentage passing sieve—			Permeability	Available moisture capacity	Reaction	Shrink-swell potential
		USDA texture	Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
	Inches							*Inches per hour*	*Inches per inch of soil depth*	*pH value*	
Olmitz (OaB, OkB).	0–27	Loam	ML–CL	A–4	----	100	60–75	0.8–2.5	0.14–0.18	5.5–6.5	Low.
For properties of the Kennebec soils in OkB, refer to the Kennebec series.	27–58	Clay loam	CL	A–7–6	----	100	70–80	0.2–0.8	0.16–0.18	5.5–6.5	Moderate to high.
Pershing (PeB, PeB2, PeC, PeC2, PrB, PrB2, PrC2, PsC3).	0–10	Silt loam	ML–CL	A–4	----	100	90–100	0.8–2.5	0.18–0.23	5.5–6.5	Low.
	10–15	Silty clay loam.	CL	A–7–6	----	100	90–100	0.2–0.8	0.19–0.21	5.0–6.0	Moderate to high.
For properties of the Grundy soils in PsC3, refer to the Grundy series.	15–34	Silty clay	CH	A–7–6	----	100	90–100	<0.05	0.15–0.18	4.8–5.5	High.
	34–56	Silty clay loam.	CL	A–7–6	----	100	90–100	0.2–0.8	0.19–0.21	5.5–6.8	Moderate to high.
Sharpsburg (SaB, SaB2, SaC, SaC2, SbC, SgC3).	0–7	Silt loam	ML–CL	A–4	----	100	95–100	0.8–2.5	0.18–0.23	6.0–6.5	Low.
	7–60	Silty clay loam.	CL	A–7–6	----	100	95–100	0.2–0.8	0.19–0.21	5.0–6.0	Moderate to high.
Shelby (ShD, ShD2, ShE, ShE2, ShF, SrE3).	0–8	Loam	ML–CL	A–4	100	95–100	60–75	0.8–2.5	0.14–0.18	6.0–7.0	Low.
	8–60	Clay loam	CL	A–7–6	100	95–100	60–75	0.2–0.8	0.16–0.18	5.5–6.8	Moderate to high.
For properties of the Gara soils in SrE3, refer to the Gara series.											
Wabash (Wa, Wb).	0–13	Silty clay loam.	CL or CH.	A–7–6	100	100	90–100	0.2–0.8	0.19–0.21	5.5–6.5	High.
	13–56	Silty clay or clay.	CH	A–7–6	100	100	90–100	<0.05	0.15–0.18	5.5–7.0	High.

RESIDENTIAL DEVELOPMENT.—Factors that have a bearing on the suitability of a site for residential development are soil drainage, the hazard of flooding, and properties of the soil material, especially of the subsoil material. The suitability of the soils for residential development is not rated in table 7, though features are named that affect suitability of the soils for septic tank filter fields. For residences constructed in areas where a municipal sewage system is not available, suitability of the soils as a filter field for septic tanks is important.

Factors that most limit suitability of a soil for use as a filter field for septic tanks are slow permeability, slow internal drainage, steep slopes, a high water table, and flooding. Table 7 rates the limitations of the soils for filter fields, as well as naming features that limit suitability. For all the soils, the limitations were rated as either "moderate" or "severe." Requirements for lagoons for sewage disposal fields are similar to those for reservoirs for ponds. Lagoons are not generally constructed where the slopes are steeper than 7 percent.

Soils that are subject to flooding or that have slow permeability, slow internal drainage, or a high water table are not only unsuitable for use as filter fields for septic tanks but also make poor sites for construction of basements. In those soils constructing a dry basement is difficult. An area to be used for constructing a basement should be free of seepage spots and should have good surface drainage.

The Gara and Shelby soils are the most desirable for use as building sites. The Clarinda, Edina, Grundy, Ladoga, Lagonda, Pershing, and Sharpsburg soils are undesirable for residential development, because they are subject to high potential shrinking and swelling and have moderately slow to very slow permeability. As a result, seepage is likely to occur in basements dug in those soils. Hillside seeps are common in areas of Lagonda and Clarinda soils,

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TABLE 7.—*Interpretation of*

Soil series and map symbol	Suitability as source of—		Soil features affecting	
	Topsoil	Highway subgrade material	Highway location	Ponds: Reservoir areas
Adair (AaB2, AsC, AsC2, AsC3). For properties of the Shelby soils in the AsC, AsC2, and AsC3 mapping units, refer to the Shelby series.	Good	Poor to fair	Moderate slopes; erodibility; plasticity of soil material.	Slow permeability; generally no hazards.
Alluvial land (Au)	Fair to poor	Poor to fair	Susceptibility to occasional flooding; seasonal high water table.	Slow permeability; normally suitable for dug ponds.
Clarinda. Mapped only in undifferentiated units with Lagonda soils.	Good	Poor to very poor	Moderate slopes; erodibility; high plasticity; moderate to high susceptibility to frost action.	Very slow permeability; no hazards.
Edina (EbA)	Good to a depth of 9 inches; fair at depths between 9 and 18 inches.	Poor	Moderate susceptibility to frost action; high plasticity.	Very slow permeability; the watershed areas are generally small.
Gara (GaD2, GaE2, GaF, GrF3)	Good	Poor to fair	Steep slopes; erodibility	Moderately slow permeability; some areas at low elevations shallow to bedrock.
Grundy (GsB, GsB2, GuA, GuB, GuC2).	Good	Poor	Moderate susceptibility to frost action; high plasticity.	Slow permeability; generally no hazards.
Kennebec (Kc)	Good to a depth of several feet.	Fair	Nearly level; susceptibility to occasional flooding.	Moderate permeability; nearly level.
Keswick (KeC, KeC2, KkC2, KkD2, KsC3, KvC3, KvD3).	Fair if fertilizer is added.	Poor to fair	Moderate slopes; erodibility.	Slow permeability; generally no hazards.
Ladoga (LaB, LaC2, LaD2, LbB, LbC2).	Fair	Poor to fair	Moderate slopes; erodibility.	Moderately slow permeability; generally no hazards.
Lagonda (LcC, LcC2, LcC3). Mapped only in complexes with Clarinda soils. For properties of the Clarinda soils, refer to the Clarinda series.	Good	Poor	Moderate slopes; erodibility; high plasticity; moderate susceptibility to frost action.	Slow permeability; no hazards.
Nevin (Ne)	Good	Poor to fair	Nearly level	Moderate permeability; in places substratum not suitable for dug ponds.
Nodaway (No, Nw)	Good	Fair	Subject to frequent flooding.	Moderate permeability; nearly level; not well suited to dug ponds.
Olmitz (OaB, OkB). For properties of the Kennebec soils in OkB, refer to the Kennebec series.	Good	Poor to fair	Occasional seepy areas	Moderate permeability; generally suitable if cored to a depth of 2 to 3 feet.

engineering properties of soils

engineering practices—				Limitations for septic tank filter fields
Ponds—Con.	Terraces and diversions	Grassed waterways	Agricultural drainage	
Embankments				
Fair to good stability; slow permeability.	Soil features favorable	Erodibility; moderate slopes, but soil features generally favorable.	Rapid runoff; hillside seeps require random tile.	Severe; slow permeability; slopes of 2 to 9 percent.
Characteristics variable	Not needed; nearly level.	Topography makes grassed waterways unnecessary.	Slow runoff; occasional stream overflow makes surface drainage necessary in places.	Severe; seasonal high water table; occasional flooding.
Fair stability; impervious	Clayey subsoil; vegetation difficult to establish because of low fertility and poor tilth; construction of terraces and diversions difficult.	Erodibility; moderate slopes; subsoil low in fertility; vegetation difficult to establish.	Rapid runoff; hillside seeps require tile.	Severe; very slow permeability; slopes of 5 to 11 percent.
Fair to poor stability and compaction; slow permeability.	Clayey subsoil; vegetation difficult to establish.	Clayey subsoil exposed in deep cuts; vegetation difficult to establish where subsoil is exposed.	Slow to medium runoff; subsurface drainage difficult.	Severe; slow permeability.
Fair to good stability and compaction; slow permeability.	Areas where slopes are steeper than 12 percent not suited to terraces.	Steep slopes; erodibility	Very rapid runoff; drainage not needed.	Severe; slopes of 9 to 35 percent.
Fair to poor stability and compaction; slow permeability.	Soil features favorable	Moderate slopes; soil features favorable.	Medium runoff; drainage not needed.	Severe; slow permeability; slopes of 0 to 9 percent.
Fair stability and compaction; fair to poor resistance to piping.	Not needed; nearly level.	Soil features favorable; grassed waterways not needed, except in upland drainageways.	Soil material open and porous; drainage not needed.	Moderate; water table occasionally within 4 feet of the surface; occasional flooding.
Fair to good stability and compaction; slow permeability.	Soil features favorable	Moderate slopes; erodibility.	Rapid runoff; in places hillside seeps require random tile.	Severe; slow permeability; slopes of 5 to 14 percent.
Fair stability; good compaction; impervious.	Soil features favorable	Moderate slopes; soil features favorable.	Rapid runoff; drainage not needed.	Moderate; moderately slow permeability; slopes of 2 to 14 percent.
Fair to poor stability and compaction; slow permeability.	Subsoil clayey; vegetation difficult to establish because of low fertility of soil material.	Erodibility; subsoil exposed; vegetation difficult to establish.	Rapid runoff; hillside seeps require random tile.	Severe; slow permeability; slopes of 5 to 11 percent.
Fair stability and compaction; slow permeability.	Not needed; nearly level.	Generally not needed; nearly level.	Slow runoff; in places some surface drainage needed.	Moderate; occasional high water table but seldom flooded; moderate permeability.
Reasonable stability; fair to poor compaction; subject to piping.	Nearly level; generally not needed, but some areas require protection from upland runoff.	Not needed; nearly level.	Soil material open and porous; drainage not needed.	Severe; subject to frequent flooding.
Fair to good stability and compaction; slow permeability.	Soil features favorable; diversions needed in places to divert upland runoff.	Soil features favorable; no limitations.	Medium to slow runoff; seepy areas require tile.	Moderate; perched water table; seepage.

TABLE 7.—*Interpretation of engineering*

Soil series and map symbol	Suitability as source of—		Soil features affecting	
	Topsoil	Highway subgrade material	Highway location	Ponds: Reservoir areas
Pershing (PeB, PeB2, PeC, PeC2, PrB, PrB2, PrC2 PsC3). For properties of the Grundy soils in PsC3, refer to the Grundy series.	Good to a depth of 6 inches; fair at depths between 6 and 10 inches.	Poor	Moderate susceptibility to frost action; high plasticity; erodibility.	Slow permeability; generally no hazards.
Sharpsburg (SaB, SaB2, SaC, SaC2, SbC, SgC3).	Good	Poor to fair	On sloping ridgetops	Moderately slow permeability; generally no hazards, but some watershed areas are small.
Shelby (ShD, ShD2, ShE, ShE2, ShF, SrE3). For properties of the Gara soils in SrE3, refer to the Gara series.	Good	Poor to fair	Steep slopes; erodibility	Moderately slow permeability; no hazards.
Terrace escarpments (Te)	Fair to poor; low content of organic matter; eroded.	Fair to poor	Steep slopes; erodibility	Generally not well suited to pond reservoirs; substratum is commonly sandy or gravelly.
Wabash (Wa, Wb)	Fair to poor; high content of clay.	Poor to very poor.	High content of organic matter; seasonal high water table; moderate to high susceptibility to frost action; high plasticity.	Very slow permeability; nearly level, and watershed areas are small; suitable for dug ponds.

and they also occur in some areas of sloping Adair and Keswick soils. Factors that make some other soils unsuitable as building sites are susceptibility to flooding in areas of Alluvial land and in the Nodaway and Kennebec soils and the poor surface drainage, unfavorable soil properties, and susceptibility to occasional flooding of the Wabash soils.

Genesis, Morphology, and Classification of Soils

This section tells how the factors of soil formation have affected the development of soils in Worth County. It also discusses the morphology of soils, explains the current system of soil classification, and places the soil series in higher categories. A discussion of each soil series represented in the county and a description of a profile typical for each series can be found in the section "Descriptions of the Soils."

Formation of Soils

Soils are produced when climate, plants and animals (including man's activity), and relief, or topography, interact over a long period of time to change parent material. These factors largely determine the properties of the soil that forms at any given point on the earth. All of them affect the formation of each soil, but the relative importance of each differs from place to place.

Climate and vegetation are the active forces that gradually alter the parent material to form a soil. Relief, a latent factor, mainly influences soil drainage and runoff but also influences soil temperature and the amount of water that enters the soil.

The importance of each of these factors in forming soils is based less on their present role than on what the factors contributed in the past. Therefore, it is difficult to make precise statements about formation of the soils because of our lack of knowledge of the past. Much can be learned, however, by studying the soils and rock formations.

Parent material

The parent material of the soils of Worth County is mainly loess, glacial till, and alluvium. These materials are here discussed only briefly in relation to their effect on the formation of the soils but are discussed more fully under the heading "Geology" in the section "Additional Facts About the County."

Loess.—The development of many of the soils in the county has been influenced by loess. The Ladoga, Sharpsburg, Grundy, Edina, and Pershing soils were derived almost entirely from loess. The upper part of the profile of the Lagonda and Nevin soils formed partly in shallow loess or has loessal material mixed into the surface layer.

Most of the loess is thought to have been blown from the flood plains of the Missouri River (*14*), but some of it probably was blown from the flood plains of smaller streams. In a few places where the slopes are as steep as 10 to 12 percent, additional loessal deposits, probably blown from the valleys of nearby streams, were laid down. Because a larger amount of loess was deposited in the sloping

properties of soils—Continued

engineering practices—				
Ponds—Con. Embankments	Terraces and diversions	Grassed waterways	Agricultural drainage	Limitations for septic tank filter fields
Fair stability and compaction; impervious.	Clayey subsoil; vegetation hard to establish because of low fertility of soil material.	Deep cuts expose the clayey subsoil; vegetation difficult to establish on the exposed subsoil; erodibility.	Rapid runoff; drainage not needed.	Severe; slow permeability; has slopes of 2 to 9 percent.
Fair stability; good compaction; impervious.	Soil features favorable.	Moderate slopes.	Medium runoff; drainage not needed.	Moderate; moderately slow permeability; has slopes of 2 to 9 percent.
Fair to good stability and compaction; slow permeability.	Soil features suitable, except where slopes exceed 12 percent.	Steep slopes; erodibility.	Rapid runoff; drainage not needed.	Moderate; moderately slow permeability; has slopes of 2 to 9 percent.
Fair stability; seepy in places.	Slopes exceed 12 percent; therefore, not suitable.	Steep slopes; erodibility.	Very rapid runoff; drainage not needed.	Severe; slopes exceed 10 percent.
Clayey; poor compaction and stability.	Not needed; nearly level.	Not needed; nearly level.	Very slow runoff; seasonal high water table; surface drainage needed; subsurface drainage difficult.	Severe; very slow permeability; frequent high water table; occasional flooding.

areas than was deposited in other places in the county, part of it still remains. Where it remains, Ladoga soils have formed.

Glacial till.—Before the loess was laid down, glacial till was deposited over the limestone and shale in a thick layer that covers the county. Soils were formed in this till during the Yarmouth and Sangamon interglacial ages and during the Illinoian glacial age. During the Yarmouth interglacial age, a nearly level soil having a subsoil of dark-gray, plastic clay several feet thick formed on the till plain. This soil was later buried by loess, but the profile has since been exposed and has become truncated. On it, Clarinda and Lagonda soils have formed.

In the sloping areas of the glacial till plain, another soil developed during the Late Sangamon interglacial age. The profile of this soil was partly truncated by back wearing. Stones accumulated on the eroded surface and formed a stone line, which was later covered by sediment[9] from retreating, eroding back slopes. In these areas the subsoil of this old soil is brown or reddish brown, except in areas where the more recent prairie influence has masked the bright colors. Where geologic erosion has removed the overlying loess and has reexposed the buried soil, Adair soils have formed under prairie vegetation and Keswick soils have formed under timber. The milder slopes have 12 to 40 inches of pedisediment overlying the glacial till.

In the modern landscape in Worth County, strong relief has developed as a result of geologic erosion. The streams have cut deep into the glacial till, and the underlying bedrock and fresh till have been exposed on the lower, steeper slopes. The modern soils—Shelby and Gara—have formed in this recently exposed, slightly weathered till.

Alluvium.—Soils of alluvial origin that vary in texture, natural drainage, and natural fertility are extensive in this county. Those formed in the more recent deposits—the stratified, medium-textured Nodaway soils, for example—are near the stream channel. Wabash soils have formed in older stream-laid deposits ranging from silty clay loam to clay in texture. Gently sloping Olmitz soils have formed in material that has been moved a short distance down the slope by erosional forces.

The alluvium of stream terraces and benches is older and lies at a higher elevation than the alluvium of the present flood plains. Nevin soils have formed in this older material, which consists of stream-laid deposits of stratified material covered by loess. The Nevin soils are on low stream terraces or benches that have steep side slopes occupied by the miscellaneous land type, Terrace escarpments.

Climate

This county now has a subhumid, continental type of climate that apparently has been but little changed during the past 6,500 years (*11*). At an earlier date, however, a different type of climate appears to have prevailed. According to a study made of the occurrence of pollen in Iowa (*9*), just north of this county, the climate during the Sangamon period 20,000 to 150,000 years ago was cool and moist and was favorable for the growth of conifers. The development of the paleo Adair and Keswick soils that

[9] Called pedisediment by Ruhe (*10*).

formed in the Late Sangamon period was influenced by the cool, moist climate of that period and also by the conifer type of vegetation, as well as by changes that took place later. According to the study made of pollen, it appears that the climate became warmer after the coniferous period and, as a result, the kind of vegetation then changed from a coniferous to a deciduous type. This warming trend appears to have occurred between 6,100 and 11,600 years ago.

The pollen study indicates that two periods have occurred in which the climate has been decidedly semiarid. During each of those periods, grass, which is able to stand greater climatic extremes than trees (*1*), became dominant. The first such period occurred about 6,500 to 8,100 years ago. The second, which was even drier, occurred during the last 6,500 years.

The fairly recent reappearance of trees in the vegetation throughout the county suggests that the climate may again be becoming more humid. At the present time, enough rainfall is received to support forest vegetation.

Plant and animal life

Plants have had a great effect on the kinds of soils that have formed in this county, and man and other animals have also had a decided influence. It is known that several changes have taken place over a long period of time in the kinds of plants in the adjacent State of Iowa, and it is assumed that similar changes have taken place in Worth County. Many of the soils formed when grass was the dominant vegetation. Soils that formed under grass are generally dark colored, but those that formed under trees are light colored, are inclined to be acid, and have a thin surface layer. Soils that have formed under shifting vegetation or under mixed grass and timber have properties intermediate between those of soils formed under grass and those formed under timber.

It is believed that spruce forests covered the area between 8,100 and 11,700 years ago and that a transitional coniferous-deciduous type of forest covered the area between 6,500 and 8,100 years ago. Since the last period when the climate became semiarid, the soils have been influenced by both prairie grasses and trees. The prairie grasses were mainly indiangrass and big and little bluestem. The trees were mainly oak, hickory, walnut, ash, maple, and similar species.

Coniferous and deciduous forest vegetation during the Late Sangamon period was apparently responsible for the reddish colors and strong blocky subsoil structure of the Adair and Keswick soils. Prairie vegetation was probably responsible for the dark color of the Edina, Grundy, Nevin, Sharpsburg, and Shelby soils, which developed entirely under grass.

The profiles of the Gara, Ladoga, and Pershing soils show evidence that the kind of vegetation changed during the time those soils were developing. The early development was dominated by grass. More recently, however, trees invaded and changed some of the soil properties. Nevertheless, the color, and the structure and content of organic matter in the subsoil, still reflect the influence of grass. The Keswick soils appear to have been the least influenced by grass of any of the soils.

Earthworms, millipedes, moles and other burrowing animals, as well as larger mammals, including man, disturb the soils, but bacteria and fungi probably contribute more toward development of soils than do animals. Bacteria and fungi cause rotting of the organic matter, improve soil tilth, and fix nitrogen in the soils, and thus increase fertility. They directly affect the soils through their activities and also exert an indirect influence through their effects on plants (*17*). The population of soil organisms is directly related to the rate of decomposition of the organic matter in the soil. The kinds of organisms and their activities vary according to the conditions in the soil and differences in the kinds of vegetation.

The absence of oxygen sharply limits the growth of nearly all kinds of fungi. Therefore, fungi are not active in a waterlogged soil. Fungi in forest litter influence the development of podzolized soils under coniferous and some mixed hardwood and coniferous stands of trees. The development of the Adair and Keswick soils may well have been affected as a result of release by microbes of nitrogen, carbon, phosphorus, and minerals contained in the organic matter.

Living organisms facilitate entrance of air and water into the soil and thus contribute to the chemical and physical processes that are active. The kinds of organisms and their activities vary according to conditions in the soil and differences in the kind of vegetation.

During the past 100 years, man has influenced the soils of this county. By clearing the trees, plowing the sod, introducing new plants, adding fertilizer and lime, providing drainage, and controlling the water and accelerated erosion, he has altered the physical and chemical properties of soils. As a result of clearing the land and plowing the sod, accelerated erosion has occurred to some degree in most soils of the county. In about one-third of the acreage of eroded soils, nearly all of the original surface layer has been lost. The content of organic matter has greatly decreased in the areas that have been cultivated. Even in fields where the soils are not eroded, the surface horizons have been changed and mixed by plowing. The natural soil structure of the surface horizons has been altered or destroyed. In many places land smoothing and other practices used to prepare the soils for irrigation or development have made even greater changes.

Relief

The soils of the county show the effects of relief in the thickness, color, and degree of development of their profiles. The soils in the nearly level areas of loess-covered prairies, for example, have a thicker, darker surface layer and a more mottled subsoil than those in sloping areas. Through its influence on runoff and infiltration, relief also affects the amount of water penetrating a soil. More water enters a nearly level soil than enters a steep one. As a result, carbonates are generally at a greater depth in a nearly level soil than in a steep one.

During the Kansan glacial period, the till plain probably had nearly level or gently sloping relief. Drainage was generally poor in the nearly level areas, and a well-defined drainage pattern was not established until the Late Sangamon period. During the Late Sangamon period, the slopes of the drainageways were probably as steep as 10 percent and most were between 5 and 8 percent. The drainageways were later deepened, lengthened, and widened, however, by geologic erosion caused by strong relief. Adair and Keswick soils formed on the side slopes of these drainageways.

By causing geologic erosion, relief affected the thickness of the loess that was deposited after the Kansas glacier receded. Erosion removed the loess from the steeper slopes in a fairly short time. Now, loess occurs primarily only on the gently sloping ridgetops and benches. In the loessal areas, soils that have formed are the Edina, Grundy, Ladoga, Pershing, and Sharpsburg.

During the time the loess was being deposited, and also after that time, streams cut deeper into the glacial till and, in a few places, into the underlying bedrock. Till that had not previously been subjected to weathering was then exposed. Where this cutting took place, the side slopes are as steep as 10 to 35 percent. The modern soils that have formed in these steep areas of fresh till are the Shelby, developed under grass, and the Gara, developed under timber.

Time

Other factors being equal, the length of time a soil material is subjected to weathering is reflected in the degree of profile development. In this county the Nodaway soils are examples of young soils. They have formed in alluvium deposited so recently that distinct horizons have not had time to develop. In those soils the strata in the alluvium are still strongly evident and the downward movement of clay and the leaching of carbonates from the surface layer have only begun. Some other soils formed in alluvium show weak horizonation.

Older soils in this county are the Sharpsburg, Grundy, and Edina formed in loess. The exact age of those soils is not known, but conditions may have become favorable for the accumulation of loess at the time of the earliest advance of the Wisconsin (Iowan) ice (*10*) about 29,000 to 35,000 years ago (*11*). The age of the Tazewell loess, just across the line in Iowa, however, is between 15,000 and 17,000 years, and it may be that the loess in Worth County is of about the same age. The soils that formed in loess show different degrees of development, though all of the loess throughout the county was deposited at about the same time. One reason for differences among these soils is that erosion, caused by sloping relief, removed much of the products of weathering, almost as fast as those products accumulated, from areas where some soils were forming.

Still older soils are the Adair, Keswick, and Clarinda. These soils have a subsoil of silty clay or clay and bear little resemblance to their parent material. The subsoil of the Adair and Keswick soils consists of remnants of a soil that developed during the Late Sangamon age, or about 38,000 years ago. That prehistoric soil, now represented by the Clarinda soils, formed in Kansan glacial till during the Yarmouth interglacial period and is several hundred thousand years old.

Soil Morphology

Soil morphology refers to the makeup of a soil, including the texture, structure, consistence, color, and other physical, mineralogical, and biological properties of the various horizons that constitute the soil profile (*17*). In all soils certain processes have acted to cause the formation of horizons. The processes most apparent in the formation of horizons in the soils of this county are (1) accumulation of organic matter, (2) leaching of carbonates and other soluble salts, (3) reduction and transfer of iron, and (4) the formation and translocation of silicate clays.

The content of organic matter ranges from very high to low in the soils of the county. Upland soils that formed under grass and poorly drained or very poorly drained, mottled soils that formed under marsh plants or swamp forest have a thick, dark-colored A1 horizon and a high content of organic matter. In those soils the content of organic matter gradually decreases with increasing depth.

Soils that contain less organic matter are those that formed under forest but that are intergrading toward soils formed under prairie. Those soils have a thin covering of organic matter on the surface and contain a thin organic-mineral horizon. They also contain a grayish-brown, leached layer and have a brown B horizon richer in clay than the overlying layer. Other soils that contain less organic matter than the soils formed under prairie are those that formed on uplands under a cover of either grass or forest in a humid or subhumid climate. Those soils have an eluviated surface horizon underlain by a B horizon more strongly illuviated, cemented, or compacted than that of normal soils with which they occur.

Leaching of soluble salts is among the first of the processes that begin the weathering of a soil. The less stable minerals are weathered sooner than the others, and carbonates and sulfates are among the first minerals to be leached out. Carbonates are at a depth of about 40 inches in the Shelby soils and are generally at a much greater depth in the other soils of the uplands. The leaching of salts causes the soil profile to have a more acid reaction than it had originally.

Reduction and transfer of iron takes place in wet soils that have a high content of organic matter. The gray color of wet soils indicates that iron has been reduced from ferric oxide (Fe_2O_3) to ferrous oxide (FeO). When free oxygen is absent, soil micro-organisms consume oxygen from iron oxide, causing the iron to be reduced and become soluble. Some soils contain red and yellow mottles and concretions, indicating that iron has been segregated.

The kinds of clay formed in a soil are related to the degree of weathering. No mineralogical analyses are available for the soils of this county. It is believed, however, that the decrease in minerals other than quartz is lowest in an arid climate, next lowest in a temperate climate under prairie, and greatest under a humid climate under timber (*5*). Resistant oxides that generally occur only in tropical regions are the end products of extreme weathering. Montmorillonite and illite are clay fractions that normally occur in dry or cold regions. Kaolinite is dominant in warm, humid regions. The soils of this county probably contain both montmorillonite and kaolinite clays. The Clarinda, Adair, and Keswick soils are older and more weathered than the other soils and therefore contain more kaolinite.

Silicate clays have developed from such primary minerals as feldspars, micas, amphiboles, and pyroxines (*6*). In the weathering process, these minerals undergo slight alterations, or in some cases, a complete decomposition and recrystallization to form silicate clays. As weathering takes place, the silicate clays are also translocated in the soil profile. They leach out of the surface horizon and accumulate in the subsoil along with compounds of iron and aluminum. The translocation of clay minerals has contrib-

uted to the development of horizons in most of the soils of this county.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationships to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First, through classification and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

Thus, in classification soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and applied in managing farms, fields, and woodlands; in developing rural areas; in performing engineering work; and in many other ways. They are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*3*) and later revised (*16*). The system currently used was adopted for general use by the National Cooperative Soil Survey in 1965. The current system is under continual study (*13, 18*). Therefore, readers interested in developments of this system should search the latest literature available.

In table 8 the family, subgroup, and order of the current system are given for each soil series. The classes in the current system are briefly defined in the following paragraphs.

ORDER: Ten soil orders are recognized in the current system. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate the soil orders are those that tend to give a broad climatic grouping of soils. Two exceptions, Entisols and Histosols, occur in many different climates.

Table 8 shows the three soil orders in Worth County—Alfisols, Entisols, and Mollisols. Alfisols are soils that have a clay-enriched B horizon high in base saturation. Entisols are recent mineral soils that do not have genetic horizons or have only the beginnings of such horizons. Mollisols are soils that have a thick, dark, friable surface layer. Their name was derived from the Latin word *mollis*, meaning soft.

SUBORDER: Each order is subdivided into suborders, primarily on the basis of those soil characteristics that seem to produce classes having the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders mainly reflect either the presence or absence of waterlogging or soil differences resulting from the climate or vegetation.

GREAT GROUP: Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated or those that have pans interfering with growth of roots or movement of water. The features used are the presence or absence of an argillic horizon or albic (A2) horizon, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The great group is not shown separately in table 8, because it is the last word in the name of the subgroup.

SUBGROUP: Great groups are subdivided into subgroups, one representing the central (typic) segment of the group and others, called intergrades, that have properties of one great group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is Aquic Argiudolls.

FAMILY: Families are separated within a subgroup, primarily on the basis of properties important to the growth of plants or behavior of soils used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence. An example is the fine, montmorillonitic, mesic family of Aquic Argiudolls.

TABLE 8.—*Classification of soil series in Worth County, Mo.*

Soil series	Family	Subgroup	Order
Adair	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Clarinda	Fine, montmorillonitic, noncalcareous, mesic, sloping.	Vertic Argiaquolls	Mollisols.
Edina	Fine, montmorillonitic, mesic	Typic Argialbolls	Mollisols.
Gara	Fine-loamy, mixed, mesic	Mollic Hapludalfs	Alfisols.
Grundy	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Kennebec	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Keswick	Fine, montmorillonitic, mesic	Aquic Hapludalfs	Alfisols.
Ladoga	Fine, montmorillonitic, mesic	Mollic Hapludalfs	Alfisols.
Lagonda	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Nevin	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Nodaway	Fine-silty, mixed, nonacid, mesic	Typic Udifluvents	Entisols.
Olmitz	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Pershing	Fine, montmorillonitic, mesic	Udollic Ochraqualfs	Alfisols.
Sharpsburg	Fine, montmorillonitic, mesic	Typic Argiudolls	Mollisols.
Shelby	Fine-loamy, mixed, mesic	Typic Argiudolls	Mollisols.
Wabash	Fine, montmorillonitic, noncalcareous, mesic	Vertic Haplaquolls	Mollisols.

Additional Facts About the County

This section describes the climate, geology, physiography, relief, and drainage of the county and gives some facts about the vegetation and agriculture. The agricultural statistics used are from reports of the U.S. Bureau of the Census.

Otoe and Musquackie Indians are among the people who first inhabited the area that is now Worth County. These people were rovers and hunters who seldom stayed in one place long enough to establish permanent dwellings and practice agriculture. The last Indians left the area about 1853.

The first settlers made their homes in wooded areas along streams. The first settlement, made in 1838, was at Lott's Grove in the northeastern part of the county, but settlements were later made at Fletchall's Grove and Black's Grove along the Middle Fork Grand River.

The county was established in 1861 from land taken from Gentry County and was named for Gen. William Jenkins Worth, a soldier of the Florida and Mexican wars. The county seat was located at its present site and was named Grant City in honor of Gen. Ulysses S. Grant.

Climate [10]

Worth County has a continental climate, typical of areas strongly influenced by warm, moist air from the Gulf of Mexico, cold air from the northern part of Canada, and warm, dry air from the southwestern part of the United States and Mexico. The area is subject to frequent large-scale changes in day-to-day temperatures, brought about by the influx of cold air from the north; warm, moist air from the south; and warm, dry air from the southwest.

Table 9 gives facts about the precipitation and temperature in the county. The data in this table were taken from records kept at Grant City from 1902 to the present time. They are considered typical for the county, though differences in elevation and relief produce local variations.

The average annual amount of precipitation received in Worth County is 34.45 inches (see table 9). About 63 percent of this amount is received during the 5 months of May through September. June is the wettest month, both in the total amount of precipitation and in the number of days on which a measurable amount (0.01 inch or more) of precipitation is received.

A study of the frequency with which a substantial amount of rainfall is received (*4*) shows that a substantial amount generally falls early in June and again early in August, and that the incidence of dry weather during that period is low. The same study shows that the amount of rainfall during the 2 weeks from July 19 through August 1 is low. Table 10, the result of that study, shows the probability of receiving at least the specified amounts of precipitation during the 2-week periods indicated. The data in table 10 are from a study made at Trenton, Mo. Though Trenton is located about 50 air miles from Grant City, the data are considered to be fairly typical of the rainfall received in summer throughout all of the northwestern part of Missouri, except that they may be slightly more extreme.

Data showing the average amount of precipitation received in July (see table 9) bear out the findings in table 10 that though the average amount of rainfall received in July is adequate for most agricultural needs, the probability of receiving a substantial amount of rainfall during July is low. Table 9 shows that only 0.69 inch or less is received in July 1 year in 10, though the average amount of rainfall received in July is 4.16 inches.

As a result of studies made of the incidence of precipitation and of dry weather (*8*), it has been suggested that plantings made early in summer should be completed prior to June 1 so that the crop and the soil will both be ready for the moisture generally received early in June. Also, planting dates and varieties of corn and soybeans should be selected that will permit the crop to enter the critical blooming and postblooming stages during the early part of August.

Most of the precipitation during July and August is in the form of thunderstorms. Rainfall is sometimes intense, and the amount of rainfall from any one storm varies greatly from place to place throughout the county. Table 9 shows the greatest amount of rainfall received during a 24-hour period during the years 1931 through 1960. On some occasions, however, an even larger amount of rainfall than is shown in table 9 has fallen during a 24-hour period. On July 10, 1922, for example, 12.25 inches of rainfall was received during a 24-hour period.

Some hail occurs in this county. Tornadoes are rare, but some have occurred. On April 29, 1947, for instance, a tornado that struck the town of Worth killed or injured many people and caused great damage to property.

The average amount of snowfall received at Grant City for each of the months December, January, and February is about 5 to 6 inches. The average figures are not an adequate guide, however, to the amount of snowfall that may be expected, because the average is obtained by adding figures from widely divergent monthly amounts. During the month of March, for example, the following amounts of snowfall were received over the 10-year period from 1953 through 1962, though the average for the whole period was 6.3 inches: 10 inches in 1953; a trace in the years 1954 and again in 1957; an estimated 1.5 inches in 1955; 2 inches in 1956; 5.5 inches in 1958 and again in 1961; 11 inches in 1959; 27 inches in 1960; and only one half inch in 1962. In only 2 of these years, 1958 and 1961, were the monthly totals for March at all close to the 10-year average of 6.3 inches.

Snowstorms occur infrequently, but a large amount of snow is generally received during each storm. In many of the months December through March, only a trace of snow has been received during the 30-year period 1931 through 1960. As much as 23 inches has been received, however, in each of these 4 months. No snowfall has been reported in April, and only traces have been reported in September. During the 30-year period when records were kept, the annual total snowfall has ranged from 3.5 inches in 1935 to 50.2 inches in 1942.

January is the coldest month. During that month, the average daily maximum temperature is approximately 35 degrees, but the temperature rises to 54 degrees or more on at least 4 days in 2 years out of 10. Conversely, the average minimum temperature in January is 15 degrees, but the temperature reaches 6 degrees below zero or lower in 2 years out of 10.

[10] By David A. Horner, acting State climatologist, U.S. Weather Bureau, Columbia, Mo.

TABLE 9.—*Precipitation*

[All data from records

Month	Precipitation								
	Average total [1]	One year in 10 will have—		Extreme values in monthly precipitation		Greatest amount of rainfall received in a 24-hour period [2]	Days with 0.01 inch or more		
		Less than [2]—	More than [2]—	Least [2]	Most [2]		Average [3]	Least [3]	Most [3]
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Number*	*Number*	*Number*
January	1.00	0.26	2.50	0.04	3.59	1.30	5	1	12
February	1.10	.30	2.20	.13	2.84	1.12	4	1	9
March	1.99	.35	3.20	.17	4.68	1.46	7	1	14
April	2.99	1.17	5.36	.71	8.56	2.39	8	3	15
May	4.29	2.23	7.18	1.54	8.05	3.53	9	5	19
June	5.21	2.26	9.88	1.25	16.82	4.27	10	5	16
July	4.16	.69	6.15	.36	10.90	3.09	6	1	10
August	4.11	1.55	8.14	.52	9.84	4.35	8	3	12
September	4.03	.76	8.47	.67	9.83	2.96	7	1	15
October	2.72	.63	4.69	0	9.17	2.41	5	0	16
November	1.74	.36	3.54	.19	8.08	2.77	6	1	13
December	1.11	.18	2.20	.11	3.28	2.01	5	1	12
Year	34.45	--------	--------	--------	--------	[4] 4.35	--------	--------	--------

[1] Based on 70 years of record in the period 1878 through 1962.
[2] Based on 30 years of record for period 1931 through 1960.
[3] Based on 23 years of record for period 1931 through 1953.
[4] Based on 58 years of record in the period 1903 through 1962.

Table 9 shows the monthly average maximum and minimum temperatures for the years 1903 through 1962 and the extreme maximum and minimum temperatures for the years 1903 through 1962. The lowest temperature recorded is 29 degrees below zero, on January 12, 1912. The highest recorded is 112 degrees on July 5, 1911. Temperatures of below zero have occurred during each of the 6 months October through March, but temperatures of below zero for 4 or more consecutive days are uncommon. Temperatures of 100 degrees or more have been reported in each of the 4 months June through September, but temperatures of 100 degrees or higher on 4 consecutive days are rare.

Worth County has a growing season of approximately 170 days. The growing season is usually defined as the interval between the last date that a temperature of 32 degrees or lower is received in spring and the first such date in fall. The temperatures are recorded in an instrument shelter approximately 5 feet above the ground. On clear, still nights, however, the temperature at plant level may be several degrees lower than that in the shelter. Furthermore, temperatures in different parts of the county vary by several degrees because of differences in elevation. Also, different species of plants vary greatly in their tolerance to freezing temperatures.

Table 11 shows the average dates of the last specified minimum temperatures in spring and the first in fall, and it gives the average number of days between those dates. Temperatures of 28 to 32 degrees have been recorded as late as May 29 in spring, however, and as early as September 24 in fall; temperatures as low as 24 to 28 degrees have been recorded as late as April 27 and as early as September 28; and temperatures of less than 24 degrees have been recorded as late as April 20 in spring and as early as October 6 in fall. This information about extreme dates of occurrence of minimum temperatures critical for the growth of plants was taken from the results of a study made at Grant City over a period of 38 years 1916–53 (*7*).

TABLE 10.—*Probability of receiving at least the specified amounts of precipitation during the 2-week periods indicated*

[From a study of records of precipitation kept from 1918 through 1954 at Trenton, Mo. (*4*)]

Weeks	Amounts of precipitation (inches)			
	1.00	1.40	2.00	2.80
	Percent	*Percent*	*Percent*	*Percent*
May 24 to June 6	74.6	64.6	51.3	37.0
June 7 to June 20	77.3	66.8	52.5	37.2
June 21 to July 4	68.5	57.7	44.3	30.9
July 5 to July 18	55.3	45.0	33.2	22.3
July 19 to August 1	46.9	31.6	16.9	7.1
August 2 to August 15	76.2	62.3	43.8	25.6
August 16 to August 29	54.1	41.4	27.4	15.6

Geology [11]

In Worth County the principal geologic units that have been identified are loess, glacial till, and shale or limestone bedrock. These materials are discussed in the following paragraphs. A knowledge of them will be helpful to engineers. Their role in the formation of soils is described briefly under "Parent Material" in the section "Genesis, Morphology, and Classification of Soils."

[11] By CHARLES ALLENDER, geologist, Missouri State Highway Department.

and temperature data

at Grant City, Mo.]

Precipitation—Continued			Temperature					
Snowfall			Average daily maximum [4]	Average daily minimum [4]	Two years in 10 will have at least 4 days with—		Extreme values	
Monthly average [4]	Extreme values				Maximum temperature equal to or higher than [5]—	Minimum temperature equal to or lower than [5]—	Maximum [4]	Minimum [4]
	Least [3]	Most [3]						
Inches	*Inches*	*Inches*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
5.9	6	26.0	34.8	15.0	54	−6	65	−29
5.6	6	26.7	39.1	18.7	56	−1	80	−27
3.8	6	27.0	50.9	28.8	69	10	91	−15
.9	6	6.0	63.7	40.5	81	25	93	10
0	0	0	73.8	51.1	87	39	99	22
0	0	0	82.4	60.3	94	50	105	39
0	0	0	88.5	64.7	99	56	112	48
0	0	0	86.7	63.4	97	53	111	41
0	0	(6)	79.0	55.0	92	52	105	28
.2	0	(6)	67.9	44.3	82	30	95	−3
1.6	0	7.8	51.8	30.6	70	13	84	−7
5.0	.2	23.2	38.3	19.8	56	0	71	−23
23.0	8.5	50.2	63.1	41.0	----------	----------	112	−29

[5] Based on 15 years of record for period 1948 through 1962.
[6] Trace.
[7] Exceeded in some years prior to 1931.

TABLE 11.—*Average dates of the last freezing temperatures in spring and the first in fall*

[Data are for Grant City for the years 1921 through 1950]

Temperature	Last in spring	First in fall	Average number of days between date of last freezing temperature in spring and first in fall
Degrees			
32	April 17	October 15	181
28	April 4	October 26	205
24	March 25	November 4	224
20	March 15	November 10	240
16	March 6	November 22	261

Loess.—This material has a smooth feel to the touch. It consists of well-sorted windblown material that contains no coarse material but consists of particles of fine silt or clay. The particles are nearly uniform in size and chemical composition. The age of the loess in this county has not been determined, but probably all of the deposits were laid down during the Wisconsin stage of glaciation.

Loess forms a narrow cap on the main ridgetops and divides, and it covers some other areas of the uplands. In only a few places is it more than 6 feet thick, but it is as much as 10 to 12 feet thick in places. All of the loess has been removed from the steeper slopes.

Glacial till.—This is a heterogeneous mixture of clay, silt, sand, gravel, and erratic boulders that contains a number of minor pockets of stratified sand, apparently of fluvial origin. The till was deposited directly by glacial ice, and little or no sorting of the material has taken place. The foreign fragments of rock include both igneous and metamorphic types, but Sioux quartzite is the predominant kind of large erratic. The larger erratics are slightly oriented in a northwest-southeast direction.

Apparently, the entire area that is now Worth County was formerly covered by till of Nebraskan age. This till was removed or reworked during the Kansas glaciation, and now only patchy remnants can be identified. In only a few places in these remnants has Nebraskan till been identified that has a composition similar to that of the overlying Kansan till. The areas of Nebraskan till can be identified by a layer of gumbo till, 5 to 6 feet thick, that is a highly weathered paleosol of Aftonian age. This paleosol is now covered by Kansan till.

In most places the combined thickness of the Nebraskan and Kansan tills is 50 to 60 feet, but till fills the preglacial valleys to a depth of more than 200 feet. The layer of dark-gray, unleached till is generally at least 20 feet thick.

Shale and limestone bedrock.—Bedrock of consolidated shale and limestone underlies all of this county. Shale and limestone are exposed in one place in the valley of the Platte River and also in a rather narrow band along the valleys of Big Rock Creek and the East Fork Grand River. In those places the indurated rock has had little influence on the development of the soils or on the drainage and topography. It appears, however, that the bedrock did influence the depth to which glacial till was deposited. The glacial till is thicker in the central part of the county, where it is underlain by relatively soft shale, than in other parts.

Bedrock formations in the county are of the Pennsylvanian period, Missourian and Virgilian series. Of the bedrock formations that have been recognized, the Shawnee group consists of shale and limestone; the Douglas and Peedee groups, of shale and sandstone; and the

Lansing group, of shale and limestone that contain interbedded ledges of Stanton and Plattsburg limestone. The Stanton and Plattsburg limestones crop out in the eastern part of the county. They have been quarried for local building stone, for rock to be used in the construction of highways, and for agricultural use. Because of the large amount of glacial debris covering these formations, only a limited amount of limestone has been removed along the edges of the valleys. The dip of the rock formations in the area is about 10 feet per mile towards the northwest.

During preglacial times, a rather wide, deep valley was cut in the indurated bedrock. It extends in a southeasterly direction from the area that is now the northwestern corner of the county. This valley was eventually filled with glacial debris. Before it was filled, however, the drainage pattern it formed was apparently associated with a related preglacial drainage system that extended throughout the northwestern part of Missouri.

Physiography, Drainage, and Water Supply [12]

Worth County consists of uplands that are dissected by the major streams and by numerous creeks (fig. 7). The side slopes of the uplands are steepest near the stream courses and are more gentle toward the divides. The ridges are mostly rounded but are sharp or knife edged in dissected areas where the side slopes are steep.

Elevations range from about 1,200 feet in the northwestern part of the county to 890 feet at Denver in the southeastern part. Several of the ridgetops are at an elevation about 200 feet higher than the level of the flood plains of the adjacent major streams. The main divides assume the approximate positions of the original till plains. When viewed from a distance, they appear to be a plain that is nearly uniform in elevation. The lowlands along streams range from one-half mile to a mile in width. The area is in a mature stage of geomorphic development (*15*).

Four main streams flow through the county. These are the Platte River and the East, Middle, and West Forks of the Grand River. In addition, Marlow, Big Rock, Little Rock, Bear, Fletchall, and Lotts Creeks provide drainage.

[12] Facts about the water supply are based on reports of the Missouri Division of Geological Survey and Water Resources.

The flow of the streams is undependable, because it is only intermittent. As a result, the streams are unsuitable for irrigation or municipal use, though the quality of the water is generally satisfactory. Farm ponds, lakes, and structures used to protect the watershed provide other sources of surface water. For the most part, water from the bedrock that underlies the county presumably contains minerals.

In the past most of the water for domestic use was provided by low-yielding, shallow wells (less than 50 feet in depth). The need for more water is increasing, however, and shallow wells no longer furnish an adequate supply. The yield from wells developed for household or general farm use varies but generally does not exceed 15 gallons per minute. In shallow wells the depth of the water table commonly varies from season to season, and these wells often "go dry" during periods of prolonged drought. Glacial drift underlying the county is the best potential source of ground water. Enough water to supply domestic needs could be taken from about 70 percent of the drift. In general, the water from glacial drift is high in content of total iron and in total dissolved solids and sulfates.

Irrigation wells have a yield high enough that they can be used to supply water for cities and industries, as well as water for irrigation. Actual pumping tests have not been conducted in this area, but an estimated yield of 200 to 1,000 gallons per minute is generally obtained if the wells are properly developed. The most favorable sites for irrigation wells in the county are the channels and valleys of preglacial and interglacial streams filled with sand and gravel. An area approximately 9,000 acres in extent has potential for development of irrigation wells. Figure 8 shows the areas most suitable for the development both of irrigation wells and domestic wells.

Vegetation

When the first settlers arrived, about two-thirds of the county was covered by prairie vegetation and about one-third was covered by forest. Few areas of the original prairie vegetation remain. Though some areas have never been plowed, they have been changed by grazing, mowing, fertilizing, or other activities. Some native grasses still grow in those areas.

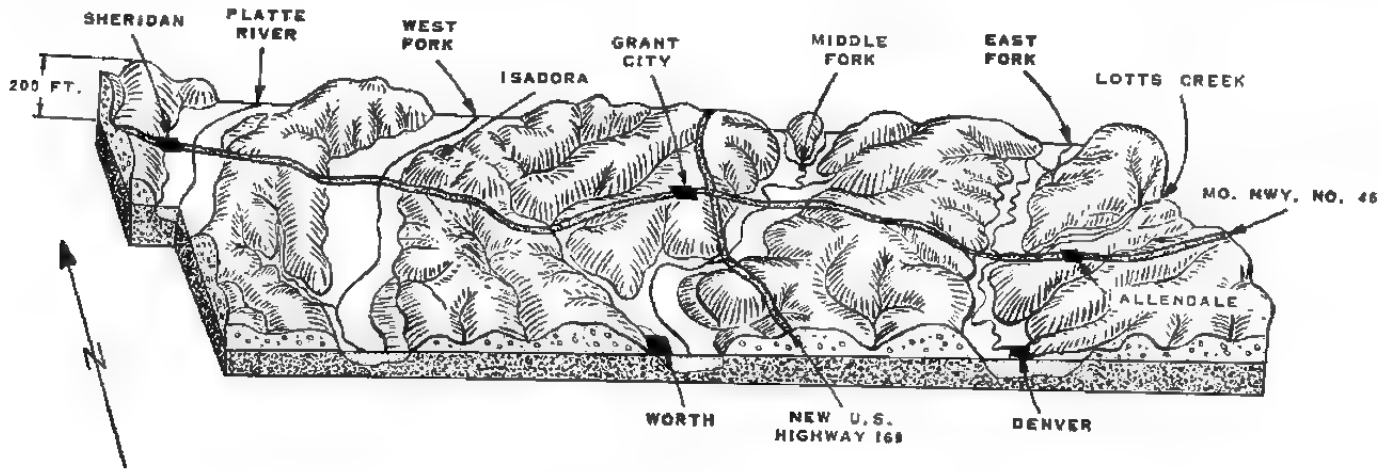

Figure 7.—Relief and drainage in Worth County.

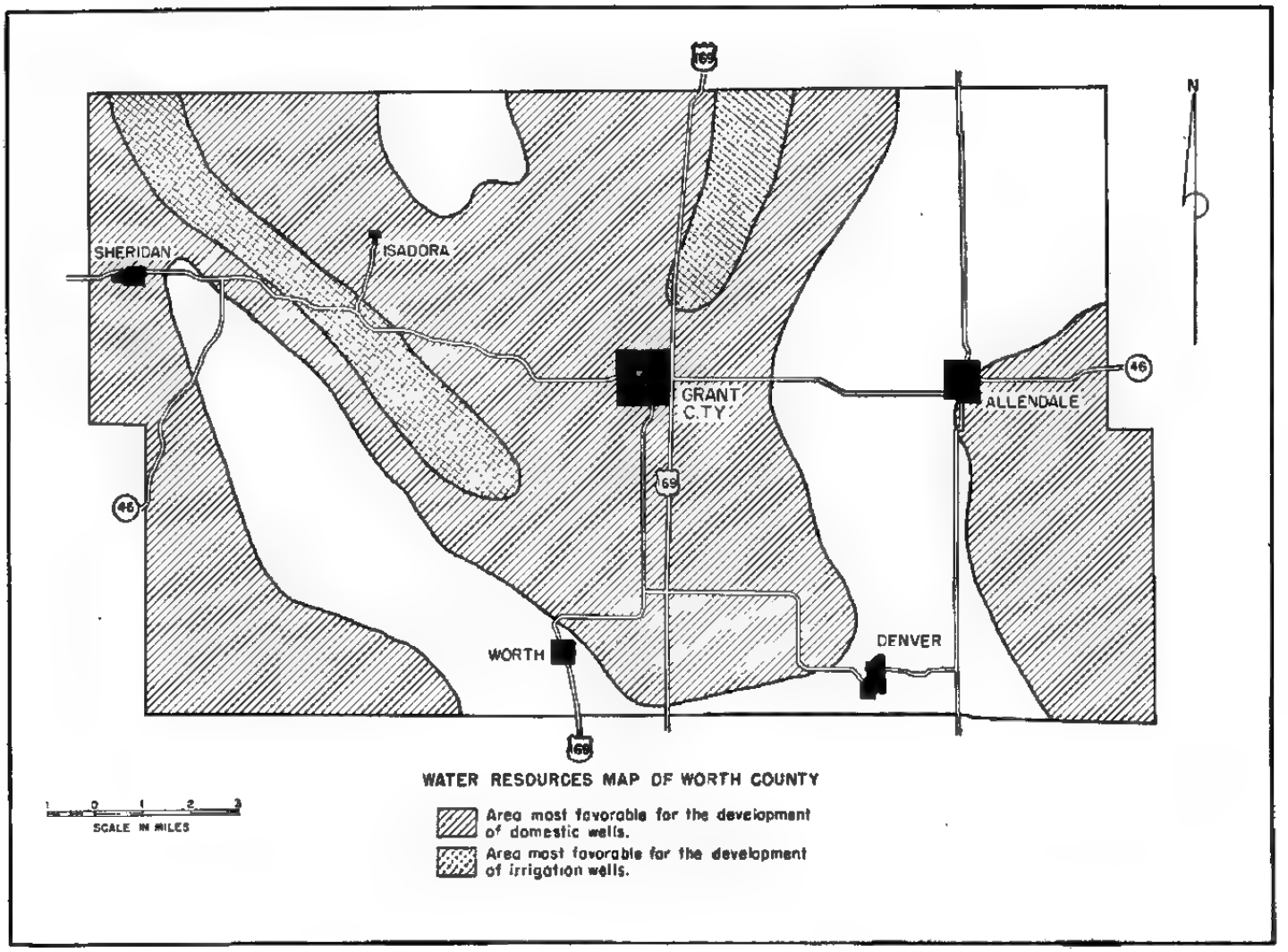

Figure 8.—**Favorable areas for the development of irrigation wells and domestic wells in Worth County.**

Timber grows mainly in narrow bands along the streams (fig. 9), but a few areas of woodland remain in the more dissected parts of the uplands. The trees along the streams are mainly willow, soft maple, ash, hackberry, elm, cottonwood, boxelder, walnut, white oak, and red oak. White oak, red oak, shingle oak, pin oak, chinkapin oak, hickory, cherry, elm, and ash are among the main trees growing in timbered areas of the uplands.

Agriculture

When the first settlers began to farm the soils of Worth County, they cultivated the timbered soils first. This was because they looked for wooded areas that would provide game for food and that would supply wood for fuel and furniture. Also, many settlers did not wish to dig the wells necessary for obtaining water in many of the prairie areas. Others simply did not believe that land that supported only grass had any value. Though the less fertile "timber" soils were planted to crops first, it was soon found that the deep, dark prairie soils produced better crops.

Today's farming in the county is based on the production of grain, hay, pasture, and livestock. Corn is the leading crop harvested for grain, and soybeans are second in importance. In 1959, a total of 22,418 acres of corn and a total of 14,536 acres of soybeans were grown for all purposes. About 93 percent of the county was in farms in 1959. The county had a total of 672 farms in that year, and the average size of farms was 237 acres.

Most farmers in the county have a herd of beef cattle, mainly of the Hereford, Aberdeen-Angus, and Shorthorn breeds. Most of the calves are sold for feeder stock, but a few farmers feed out their own calves. The dairy herds consist mainly of Holsteins, but some farmers own Jersey or Guernsey cattle. Dairy products are marketed through nearby creameries in both Iowa and Missouri. Hogs are raised throughout the county and consume a large part of the corn produced. Hampshire, Duroc, and Chester White are the breeds of hogs most commonly raised. Sheep are fairly common, and most flocks include 10 to 20 ewes. Poultry raising has decreased in importance during the past few years. Chickens are the kind of poultry raised

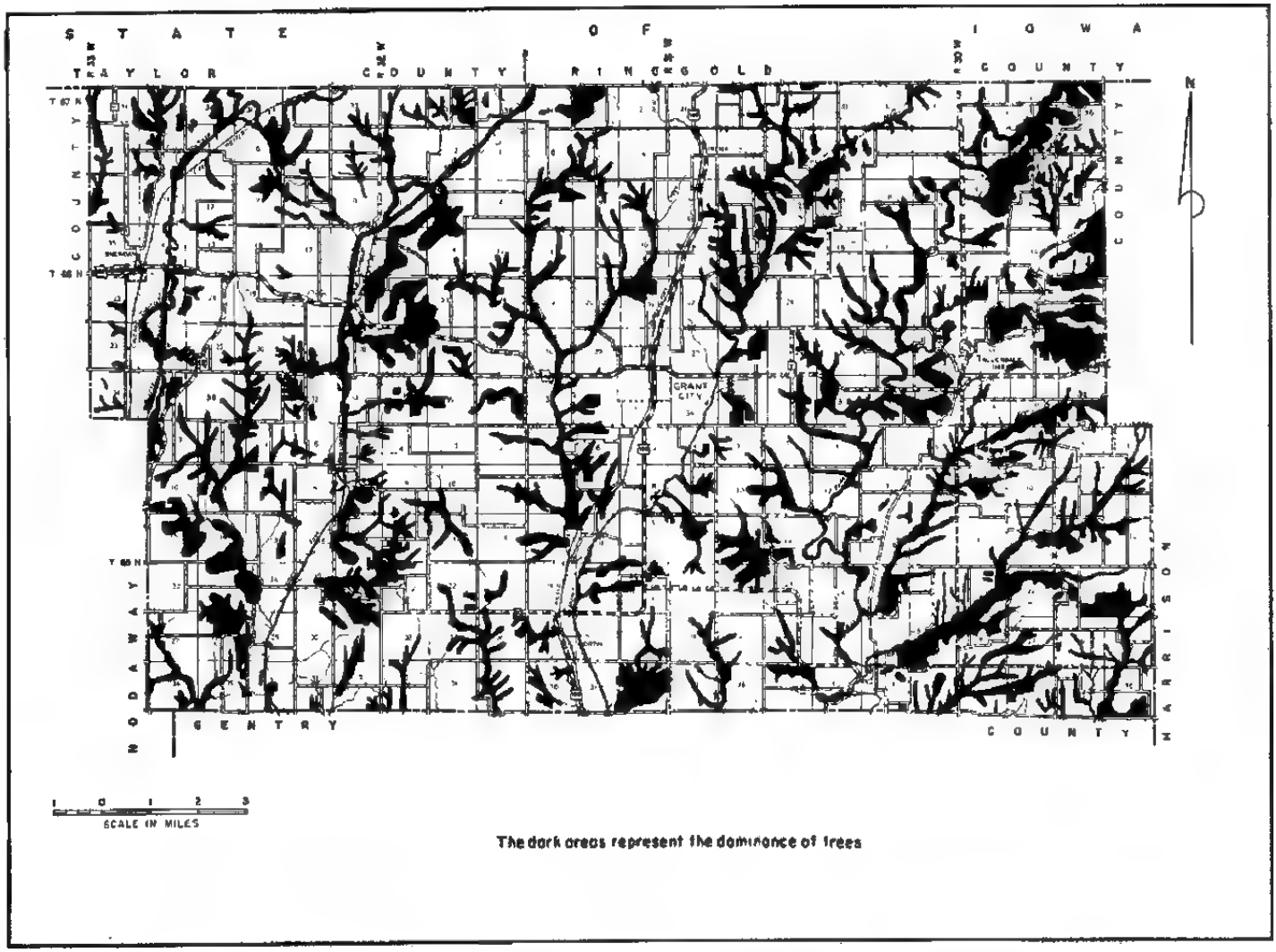

Figure 9.—Map showing the occurrence of timber in Worth County in 1957. The dark areas represent places where trees are dominant.

most extensively, but a few turkeys, ducks, and geese are raised.

In 1959 a total of 22,421 cattle and calves, including 2,089 milk cows, 28,916 hogs and pigs, 8,051 sheep and lambs, and 43,304 chickens 4 months old or older were reported in the county. In the same year, there were only 806 horses and mules.

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Glossary

Acidity. See Reaction, soil.

Aggregate, soil. Many fine particles held in a single mass or cluster, such as a clod, crumb, block, or prism.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Alluvial fan. A fan-shaped deposit of sand, gravel, and fine material dropped by a stream where the gradient lessens abruptly.

Available moisture capacity. The capacity of a soil to hold water in a form available to plants. Amount of moisture held in a soil between field capacity, or about one-third atmosphere of tension, and the wilting coefficient, or about 15 atmospheres of tension.

Bench. In this soil survey, refers to a geologic terrace that rises to an elevation 10 to 50 feet above the present flood plains but is lower than the adjacent uplands.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate.

Concretion. Grains, pellets, or nodules, of various sizes, shapes, and colors, consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent; will not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Drainage class, soil. Refers to moisture conditions that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artifical drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural drainage are recognized.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and podzolic soils commonly have mottlings below 6 to 16 inches in the lower A horizons and in the B and C horizons.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, though mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Erosion, soil. The wearing away of the land surface by wind, running water, and other geologic agents.

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Genesis, soil. The manner in which a soil originated, with special reference to the processes responsible for the development of the solum, or true soil, from the unconsolidated parent material.

Glacial till. Unsorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon. The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residue.

A horizon. The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon. The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has (1) distinctive characteristics caused by accumulation of clay, sesquioxides, humus, or some combination of these; (2) prismatic or blocky structure; (3) redder or stronger colors than the A horizon; or (4) some combination of these. The combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon. The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter, C.

R layer. Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Loam. The textural class name for soil having a moderate amount of sand, silt, and clay. Loam soils contain 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.

Leaching, soil. The removal of soluble material from soils or other material by percolating water.

Loess. A fine-grained eolian deposit consisting dominantly of silt-sized particles.

Mottled. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these—*fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Morphology, soil. The makeup of the soil, including the texture, structure, consistence, color, and other physical, chemical, mineralogical, and biological properties of the various horizons that make up the soil profile.

Organic matter, soil. Content of humus and other nonmineral material is rated in this survey as follows:

1 to 2 percent	Low.
2 to 3 percent	Medium.
3 to 4 percent	High.
More than 4 percent	Very high.

Paleosol. A buried soil, especially one developed during an interglacial period and later covered by deposits laid down during later advances of the ice.

Parent material. The disintegrated and partly weathered rock from which soil has formed.

Permeability, soil. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *Very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

pH. See Reaction, soil.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material. See also Horizon, soil.

Reaction, soil. The degree of acidity or alkalinity of a soil expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. In words the degree of acidity or alkalinity is expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Slightly acid	6.1 to 6.5
Very strongly acid	4.5 to 5.0	Neutral	6.6 to 7.3
Strongly acid	5.1 to 5.5	Alkaline	7.4 and higher
Medium acid	5.6 to 6.0		

Relief. The elevations or inequalities of a land surface, considered collectively.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 millimeter to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Silt loam. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.5 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Silty clay. Soil of this textural class contains 40 percent or more clay and 40 percent or more silt.

Silty clay loam. Soil of this textural class contains 27 to 40 percent clay and less than 20 percent sand.

Slope classes. The following slope classes are used in this soil survey:

0 to 2 percent	Level to nearly level.
2 to 5 percent	Gently sloping.
5 to 9 percent	Moderately sloping.
9 to 14 percent	Strongly sloping.
14 to 20 percent	Steep.
20 to 35 percent	Very steep.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief over periods of time.

Stratified. Composed of, or arranged in, strata, or layers, such as stratified alluvium. The term is confined to geologic material. Layers in soils that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are *platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular.* Structureless soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Terrace (agriculture). An embankment or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surplus runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so that they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea. Stream terraces are frequently called *second bottoms,* as contrasted to *flood plains,* and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. (See also Clay, Sand, and Silt). The basic textural classes, in order of increasing proportions of fine particles are as follows: Sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Topsoil. A presumed fertile soil or soil material, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

Truncated soil profile. A soil profile from which one or more of the upper horizons, normally present, have been removed by natural or accelerated erosion or by other means. Some profiles have lost part or all of the A horizon, and some have lost the B horizon, leaving as soil only the poor, undeveloped parent material, or C horizon. A comparison of eroded soil profiles of the same area, soil type, and slope conditions, indicates the degree of truncation.

Upland. Land consisting of the material unworked by water in recent geologic time and lying, in general, at a higher elevation than the alluvial plain or stream terrace. Land above the lowlands along rivers.

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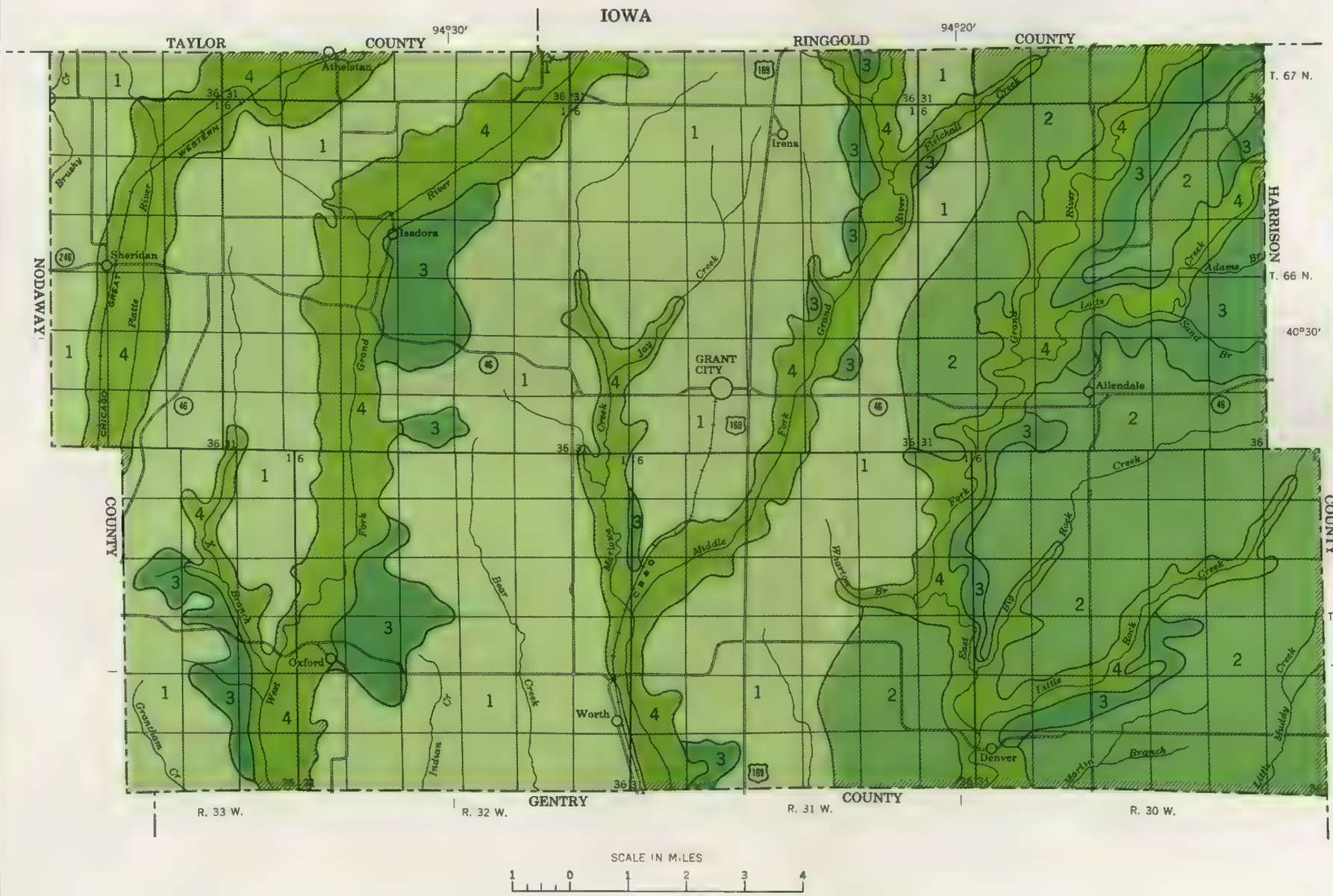
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
MISSOURI AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP
WORTH COUNTY, MISSOURI



SOIL ASSOCIATIONS

1 — Shelby-Lagonda-Sharpsburg association: Sloping to hilly, moderately well drained or somewhat poorly drained soils that have developed in glacial till on side slopes and in loess on ridgetops

2 — Shelby-Lagonda-Grundy association: Moderately sloping to hilly, moderately well drained or somewhat poorly drained soils that have developed in glacial till on side slopes, and somewhat poorly drained soils that have developed in loess on ridgetops

3 — Gara-Keswick-Pershing association: Moderately sloping to steep, moderately well drained soils that have developed in glacial till on side slopes and ridges, and somewhat poorly drained soils that have developed in loess on bench terraces and ridgetops

4 — Wabash-Nodaway-Kennebec association: Nearly level, poorly drained soils that have developed in clayey sediment, and moderately well drained or well drained soils that have developed in silty alluvium; mainly on flood plains

March 1968

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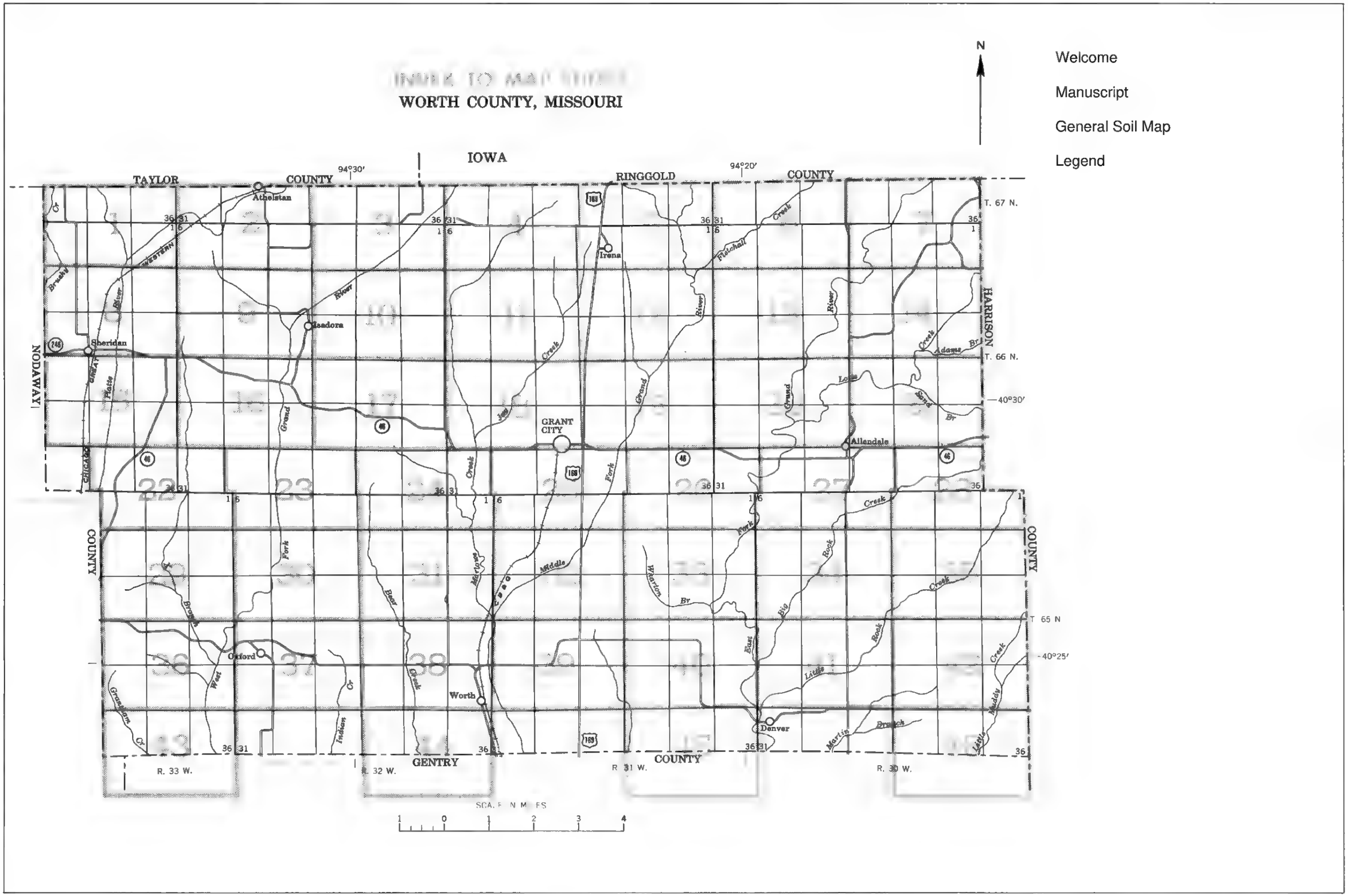

Welcome

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General Soil Map

Legend

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SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, D, E, or F, shows the slope. Most symbols without a slope letter are those of nearly level soils or land types, but some are for land types that have a considerable range in slope. Soils that are named as moderately eroded or severely eroded have a final number, 2 or 3, in their symbol.

SYMBOL	NAME
AuB2	Adair silt loam variant and Adair loam, 2 to 5 percent slopes, moderately eroded
AsC	Adair and Shelby loams, 5 to 9 percent slopes
AsC2	Adair and Shelby loams, 5 to 9 percent slopes, moderately eroded
AsC3	Adair and Shelby soils, 5 to 9 percent slopes, severely eroded
Au	Alluvial land
EbA	Edina silt loam, benches, 0 to 3 percent slopes
GaD2	Gara loam, 9 to 14 percent slopes, moderately eroded
GaE2	Gara loam, 14 to 20 percent slopes, moderately eroded
GaF	Gara loam, 20 to 35 percent slopes
GrF3	Gara soils, 20 to 35 percent slopes, severely eroded
GsB	Grundy silt loam, 2 to 5 percent slopes
GsB2	Grundy silt loam, 2 to 5 percent slopes, moderately eroded
GuA	Grundy silt loam, benches, 0 to 2 percent slopes
GuB	Grundy silt loam, benches, 2 to 5 percent slopes
GuC2	Grundy silt loam, benches, 5 to 9 percent slopes, moderately eroded
Kc	Kennebec silt loam
KeC	Keswick loam, 5 to 9 percent slopes
KeC2	Keswick loam, 5 to 9 percent slopes, moderately eroded
KkC2	Keswick loam, valleys, 5 to 9 percent slopes, moderately eroded
KkD2	Keswick loam, valleys, 9 to 14 percent slopes, moderately eroded
KsC3	Keswick soils, 5 to 9 percent slopes, severely eroded
KvC3	Keswick soils, valleys, 5 to 9 percent slopes, severely eroded
KvD3	Keswick soils, valleys, 9 to 14 percent slopes, severely eroded
LaB	Ladoga silt loam, 2 to 5 percent slopes
LaC2	Ladoga silt loam, 5 to 9 percent slopes, moderately eroded
LaD2	Ladoga silt loam, 9 to 14 percent slopes, moderately eroded
LbB	Ladoga silt loam, benches, 2 to 5 percent slopes
LbC2	Ladoga silt loam, benches, 5 to 9 percent slopes, moderately eroded
LcC	Lagonda and Clarinda soils, 5 to 11 percent slopes
LcC2	Lagonda and Clarinda soils, 5 to 11 percent slopes, moderately eroded
LcC3	Lagonda and Clarinda soils, 5 to 11 percent slopes, severely eroded
Ne	Nevin silt loam
No	Nodaway silt loam
Nw	Nodaway silt loam, overflow
OaB	Olmitz loam, 2 to 5 percent slopes
OkB	Olmitz–Kennebec complex, 0 to 5 percent slopes
PeB	Pershing silt loam, 2 to 5 percent slopes
PeB2	Pershing silt loam, 2 to 5 percent slopes, moderately eroded
PeC	Pershing silt loam, 5 to 9 percent slopes
PeC2	Pershing silt loam, 5 to 9 percent slopes, moderately eroded
PrB	Pershing silt loam, benches, 2 to 5 percent slopes
PrB2	Pershing silt loam, benches, 2 to 5 percent slopes, moderately eroded
PrC2	Pershing silt loam, benches, 5 to 9 percent slopes, moderately eroded
PsC3	Pershing and Grundy soils, benches, 5 to 9 percent slopes, severely eroded
SaB	Sharpsburg silt loam, 2 to 5 percent slopes
SaB2	Sharpsburg silt loam, 2 to 5 percent slopes, moderately eroded
SaC	Sharpsburg silt loam, 5 to 9 percent slopes
SaC2	Sharpsburg silt loam, 5 to 9 percent slopes, moderately eroded
SbC	Sharpsburg silt loam, benches, 3 to 8 percent slopes
SgC3	Sharpsburg soils, 5 to 9 percent slopes, severely eroded
ShD	Shelby loam, 9 to 14 percent slopes
ShD2	Shelby loam, 9 to 14 percent slopes, moderately eroded
ShE	Shelby loam, 14 to 20 percent slopes
ShE2	Shelby loam, 14 to 20 percent slopes, moderately eroded
ShF	Shelby loam, 20 to 30 percent slopes
SrE3	Shelby and Gara soils, 9 to 20 percent slopes, severely eroded
Te	Terrace escarpments
Wa	Wabash silty clay
Wb	Wabash silty clay loam

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads
- Dua
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- U. S.
- State or county

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail, foot
- Railroad
- Ferry (FY)
- Ford (FORD)
- Grade
- R. R. over
- R. R. under
- Tunnel

Buildings
- School
- Church
- Station

Mines and Quarries

Mine dump

Pits, gravel or other

Power line

Pipeline

Cemetery

Dams

Levee

Tanks

Well, oil or gas

BOUNDARIES

- National or state
- County
- Reservation
- Land grant
- Small park, cemetery, airport
- Land survey division corners

DRAINAGE

Streams, double-line
- Perennial
- Intermittent

Streams, single-line
- Perennial
- Intermittent

Canals and ditches (CANAL)

Lakes and ponds
- Perennial (water, w)
- Intermittent

Wells, water (flowing)

Spring

Marsh or swamp

Wet spot

Alluvial fan

Drainage end

RELIEF

Escarpments
- Bedrock
- Other

Prominent peak

Depressions (Large, Small)
- Crossable with tillage implements
- Not crossable with tillage implements
- Contains water most of the time

SOIL SURVEY DATA

- Soil boundary and symbol (Dx)
- Gravel
- Stony, very stony
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion
- Gully

Soil map constructed 1966 by Cartographic Division, Soil Conservation Service, USDA, from 1963 aerial photographs. Controlled mosaic based on Missouri plane coordinate system, west zone, transverse Mercator projection, 1927 North American datum.

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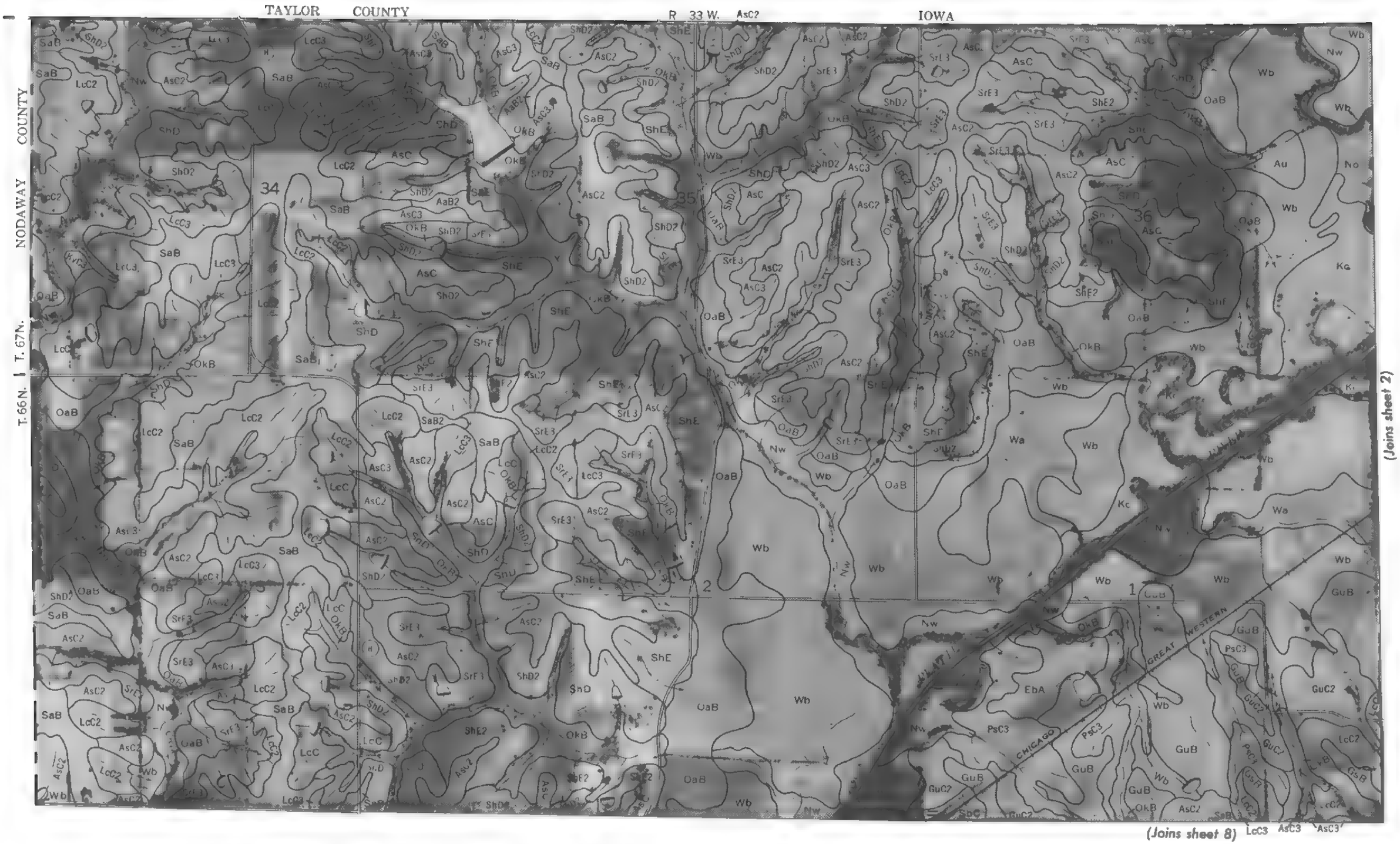

0 ½ Mile Scale 1 : 15 840 0 3 000 Feet

WORTH COUNTY, MISSOURI — SHEET NUMBER 2

0 ½ Mile Scale 1 : 15 840 0 3 000 Feet

WORTH COUNTY, MISSOURI — SHEET NUMBER 3

0 ½ Mile Scale 1 : 15 840 0 3 000 Feet

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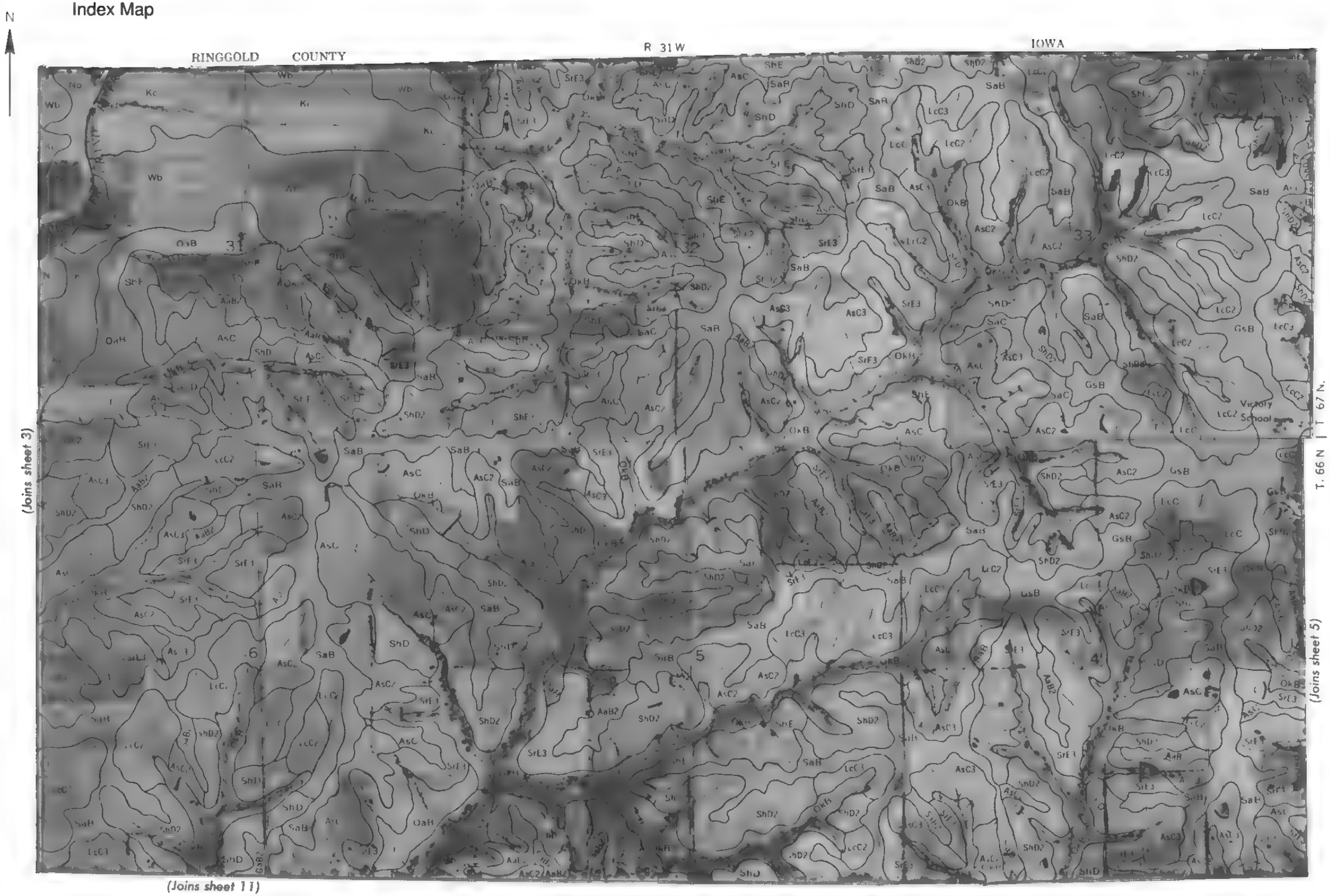

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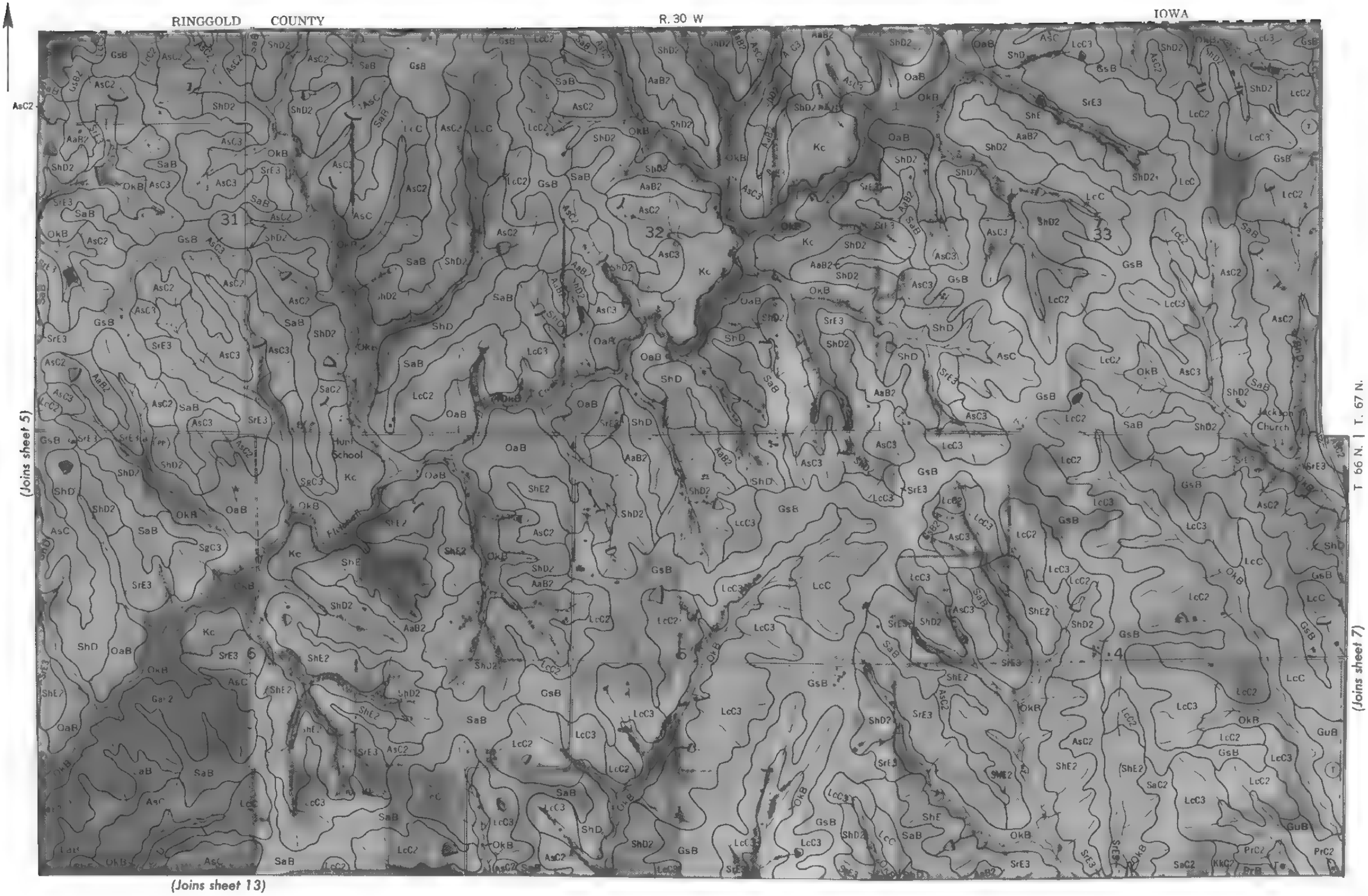
WORTH COUNTY, MISSOURI — SHEET NUMBER 6



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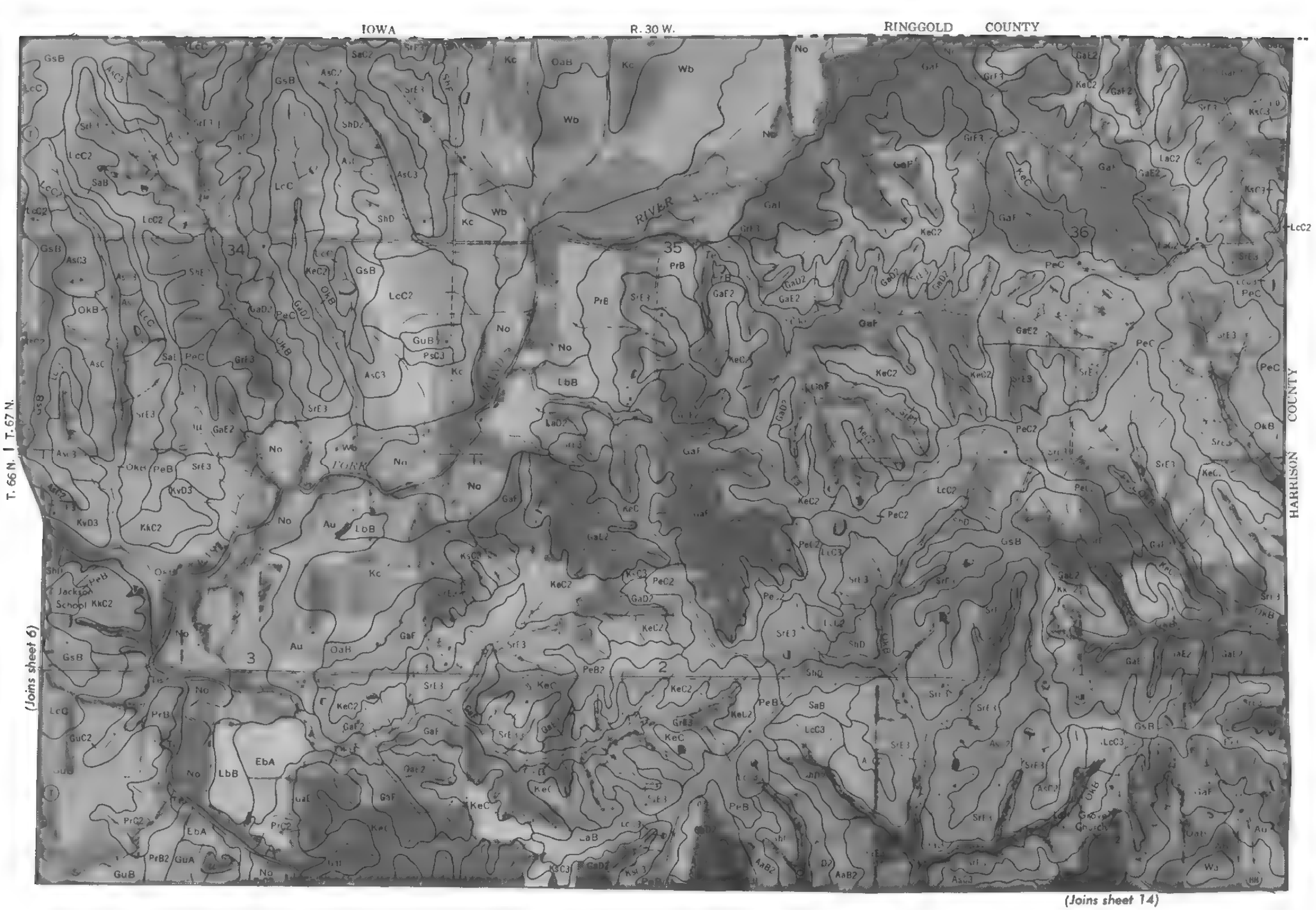

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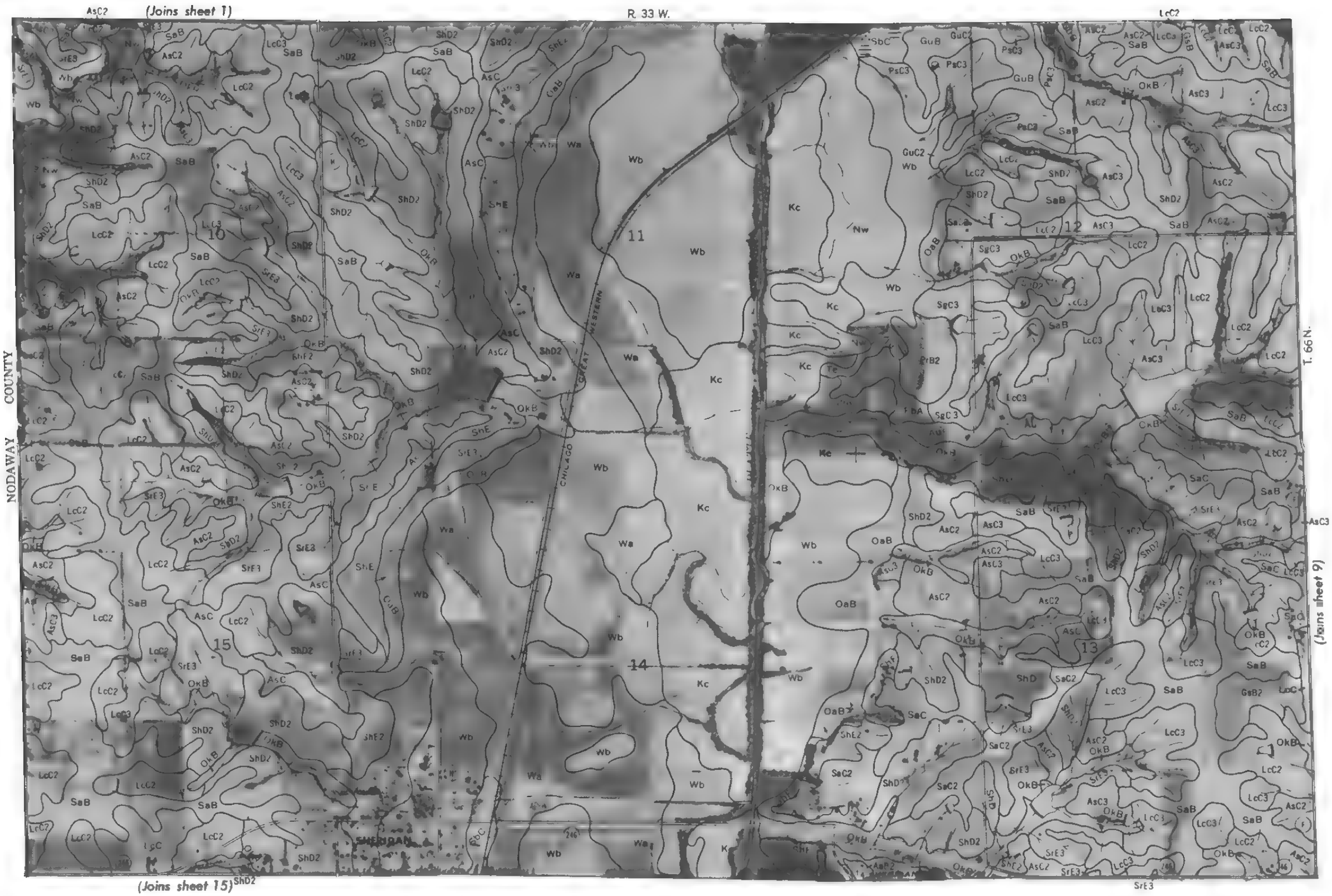

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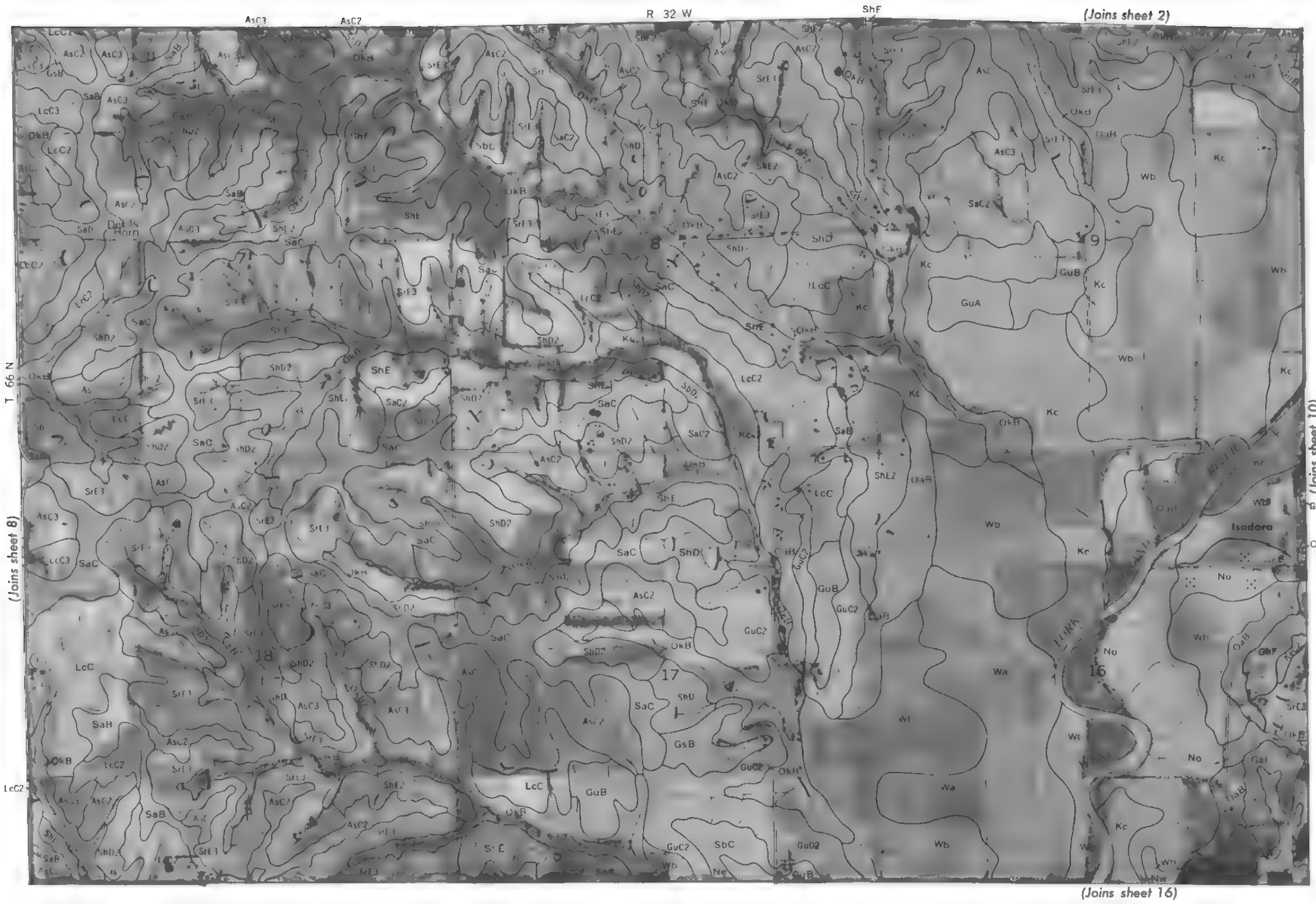

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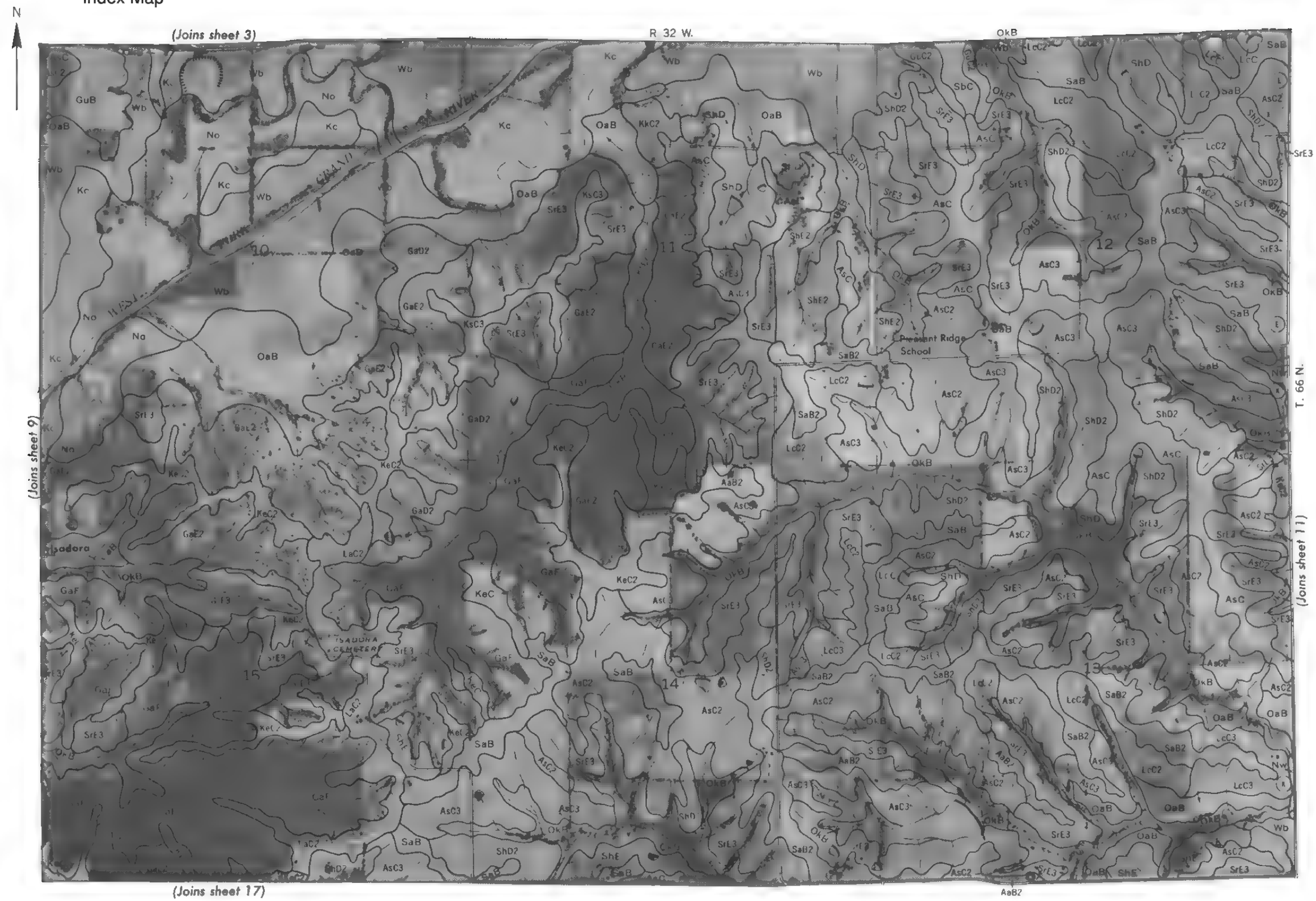

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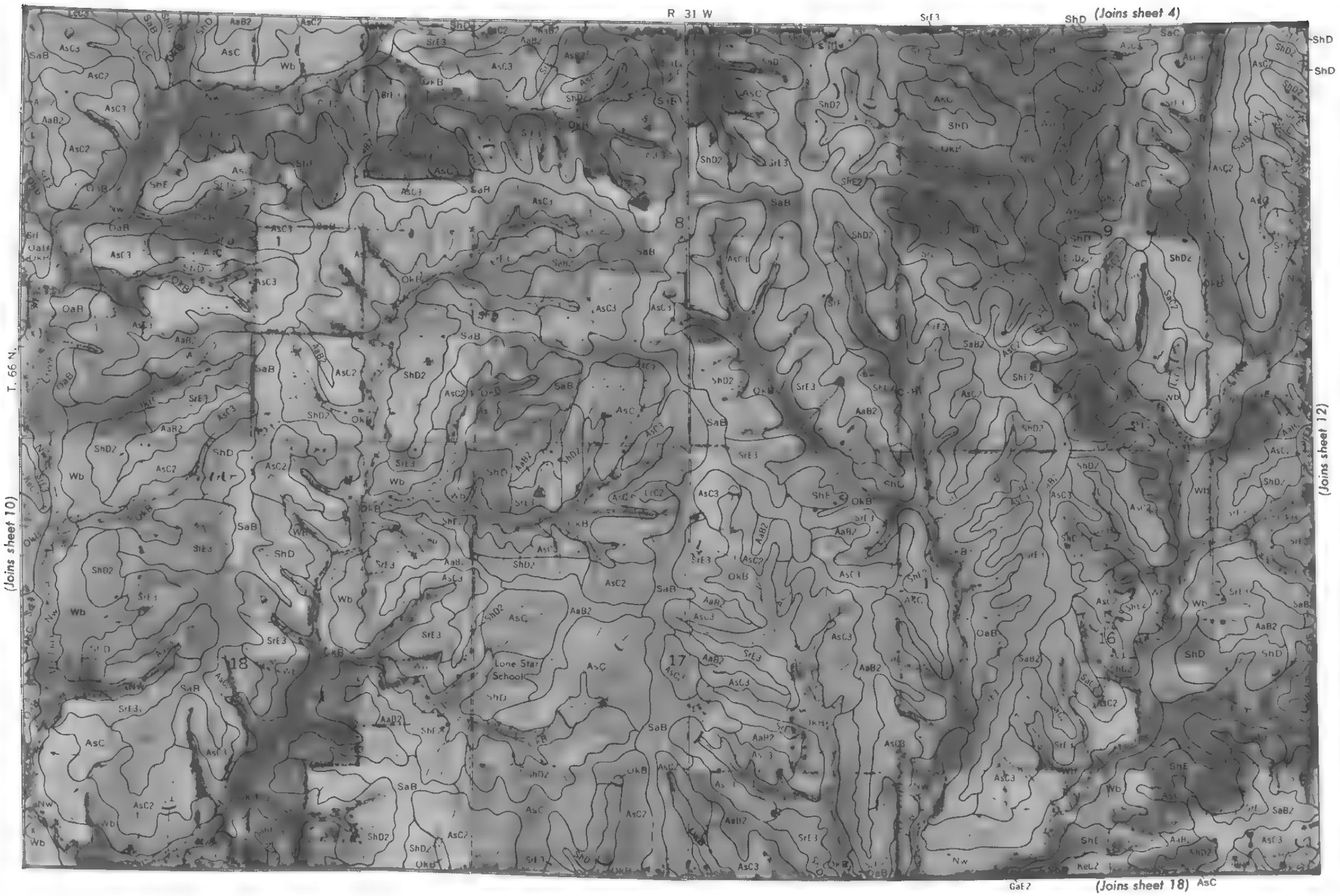

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WORTH COUNTY, MISSOURI — SHEET NUMBER 12

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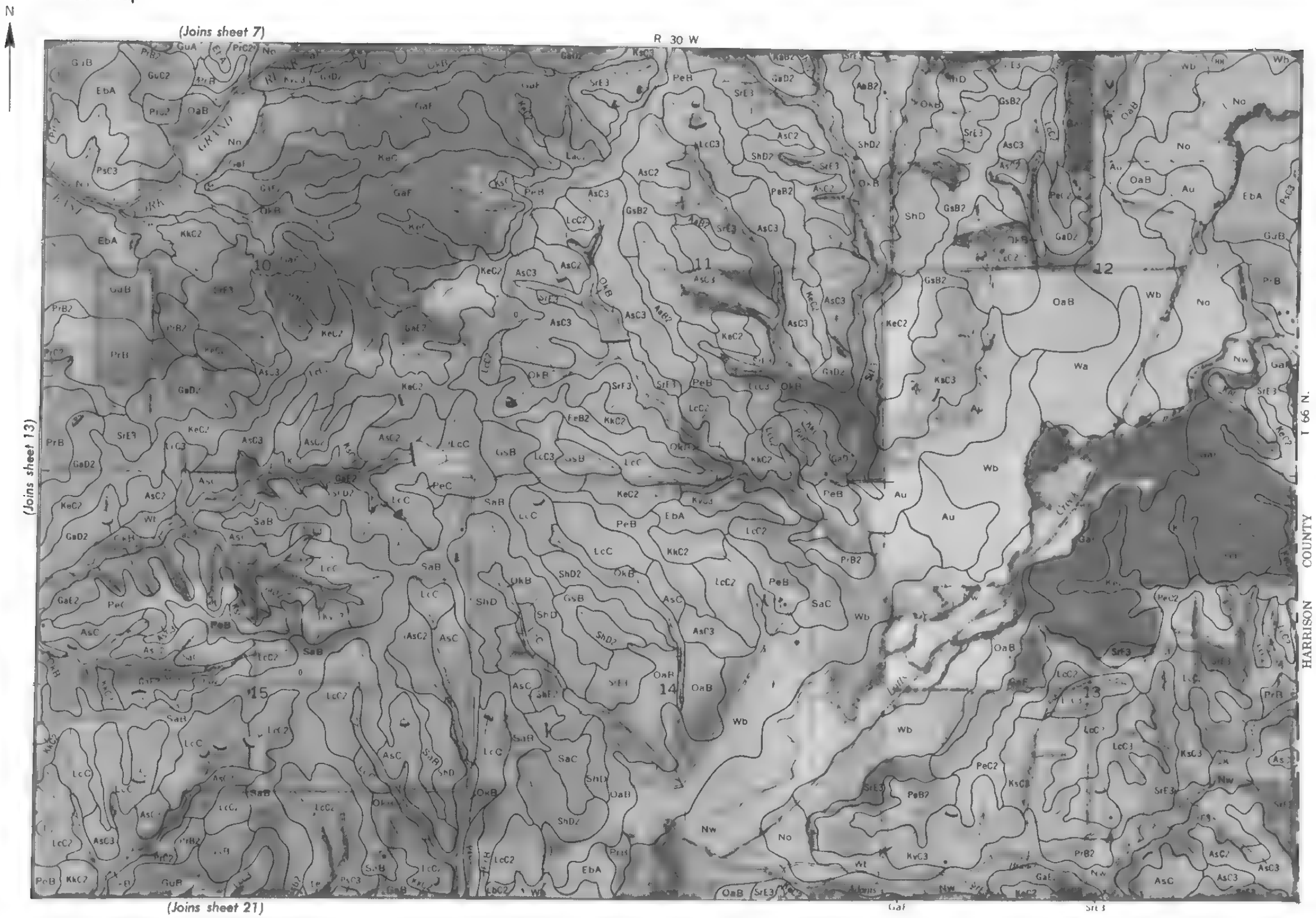

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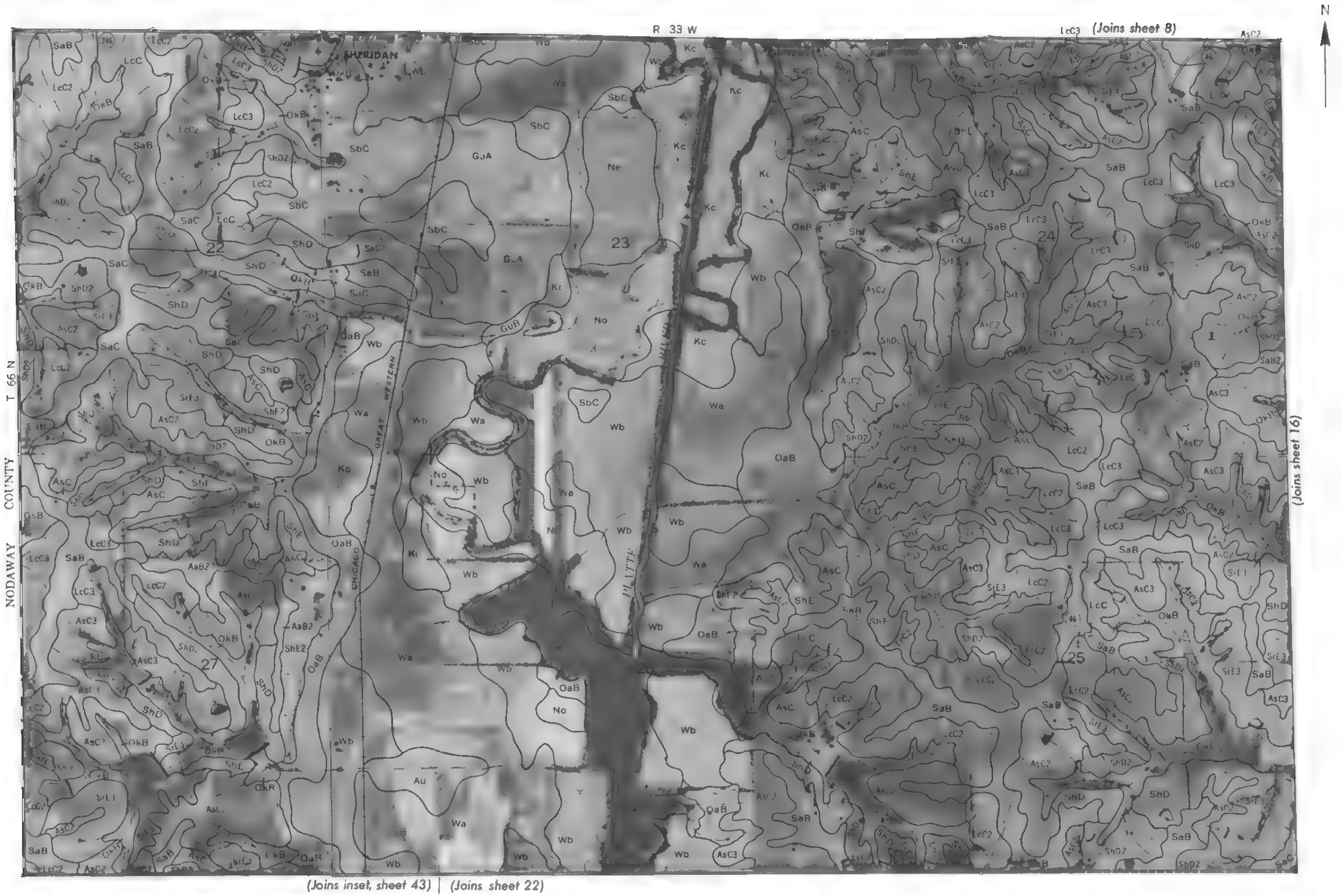

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0 ½ Mile Scale 1 : 15 840 0 3 000 Feet

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WORTH COUNTY, MISSOURI — SHEET NUMBER 18

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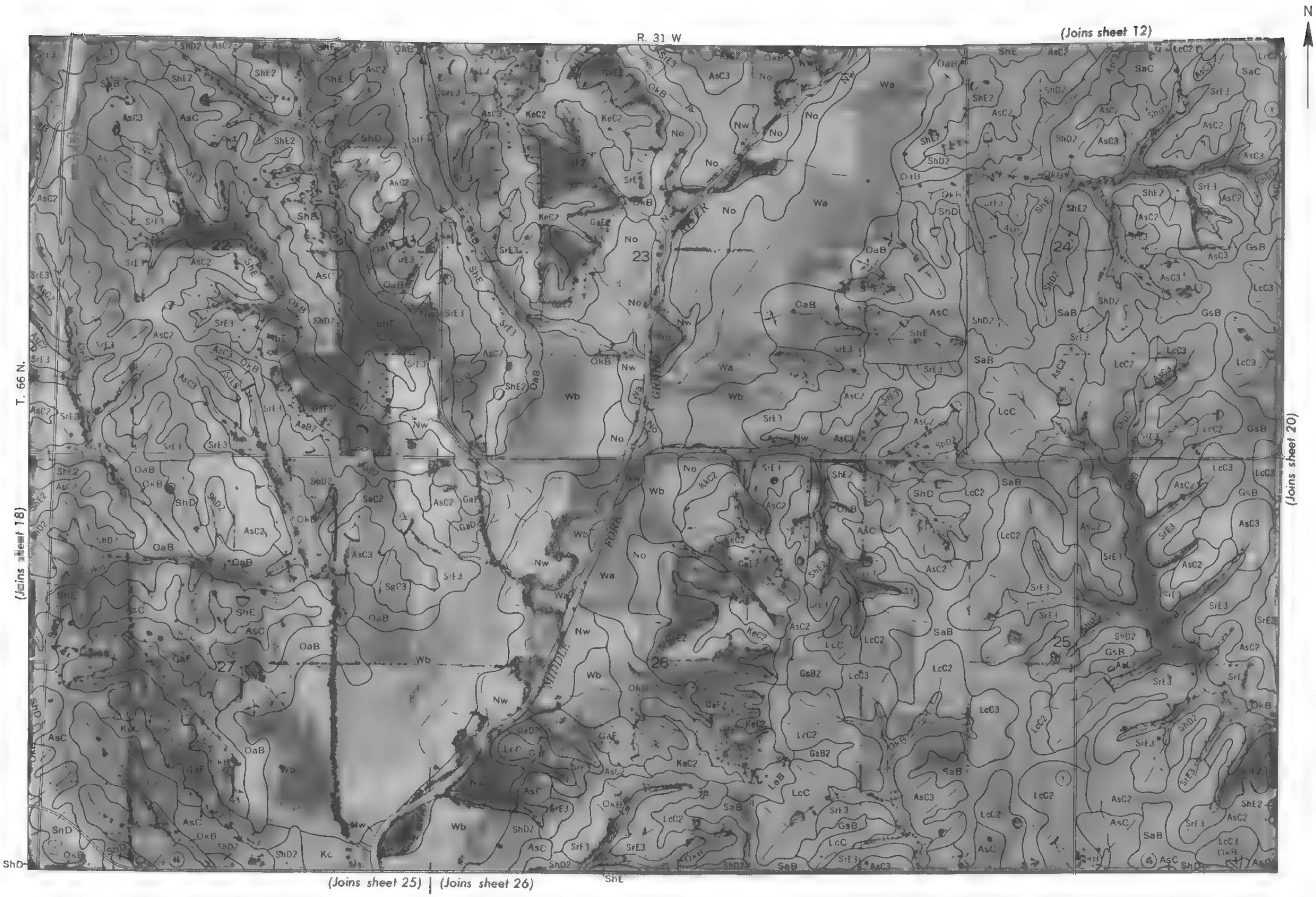

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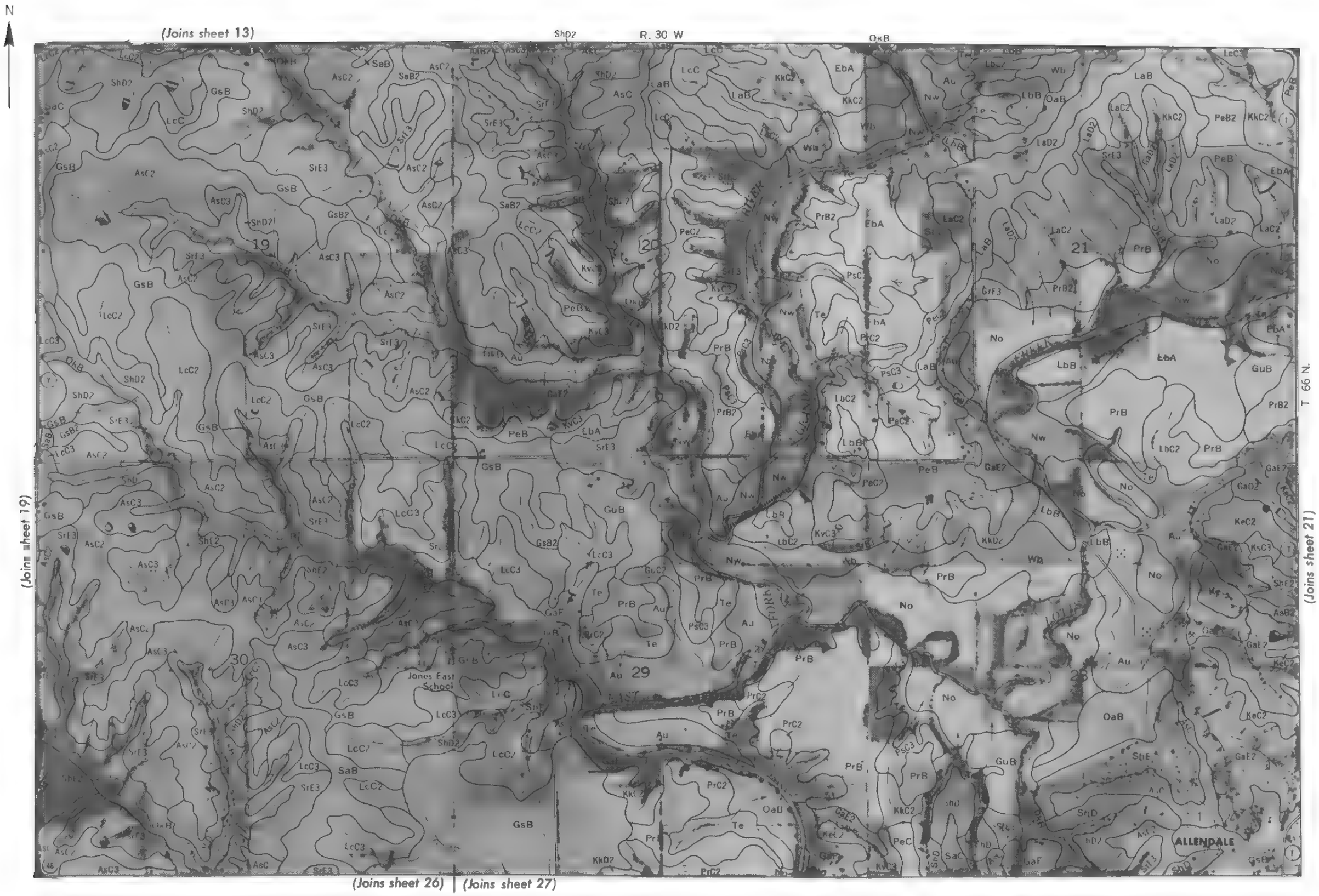

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0 ½ Mile Scale 1 : 15 840 0 3 000 Feet

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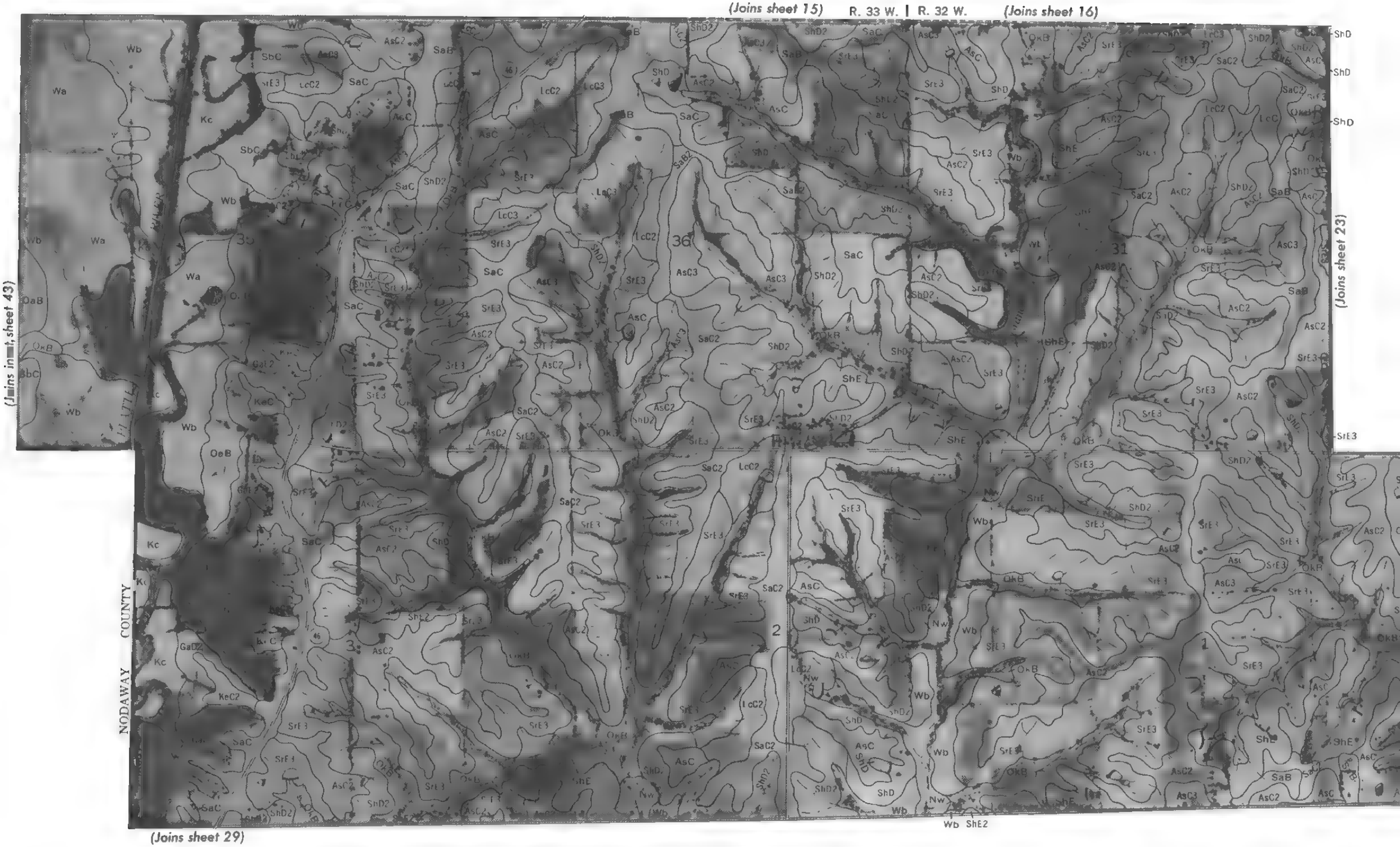

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0 ½ Mile Scale 1 : 15 840 0 3 000 Feet

WORTH COUNTY, MISSOURI — SHEET NUMBER 24

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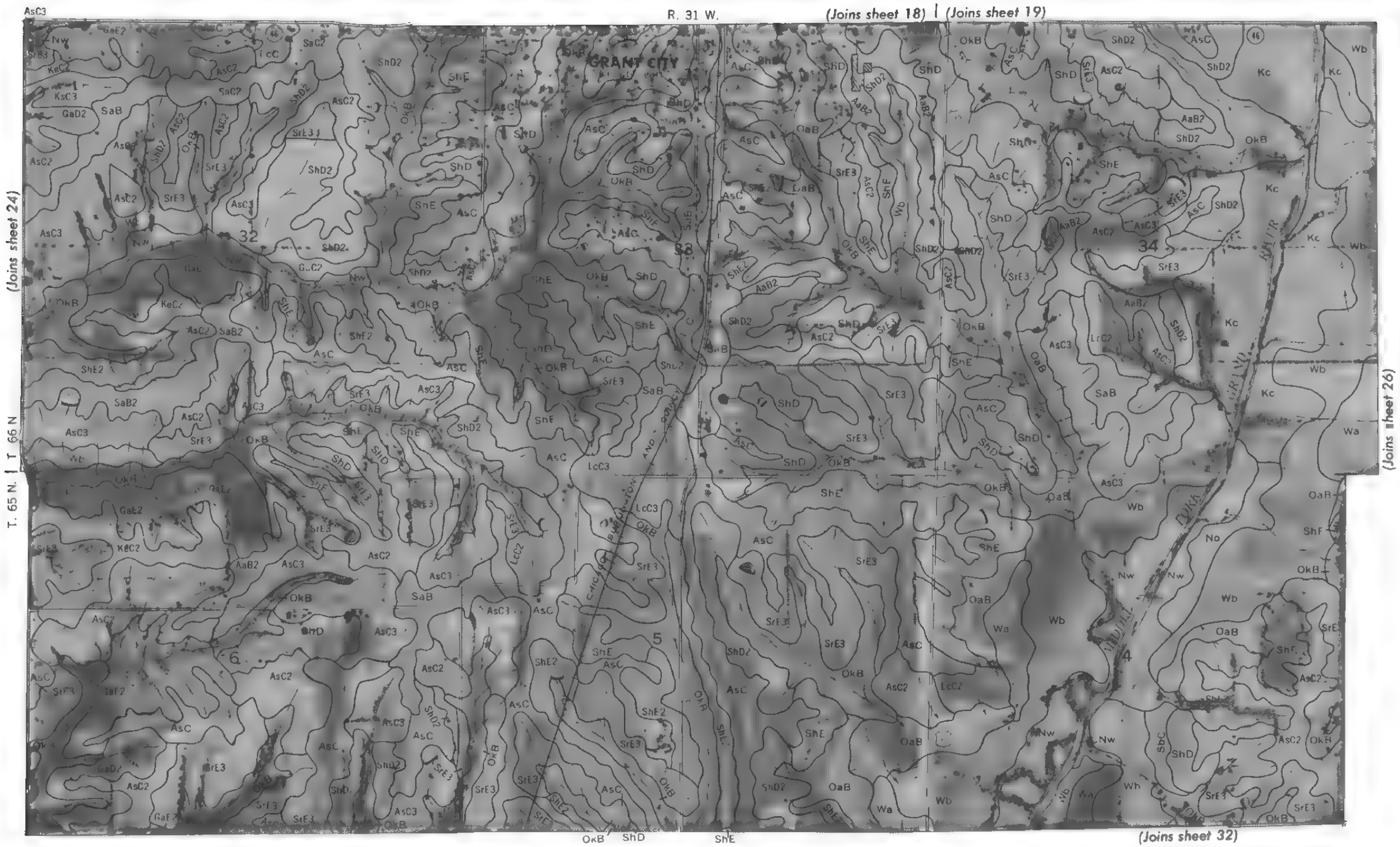

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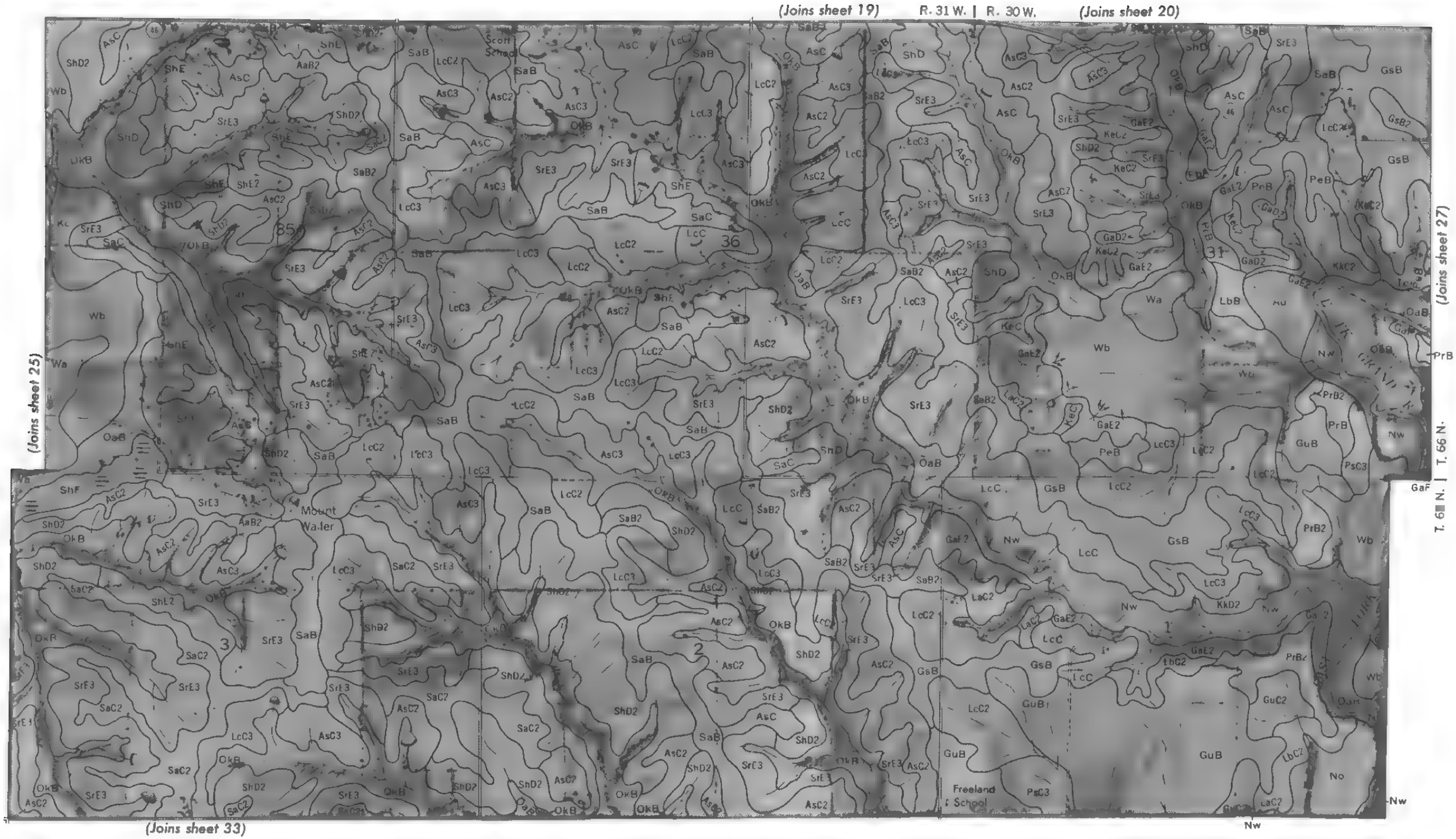

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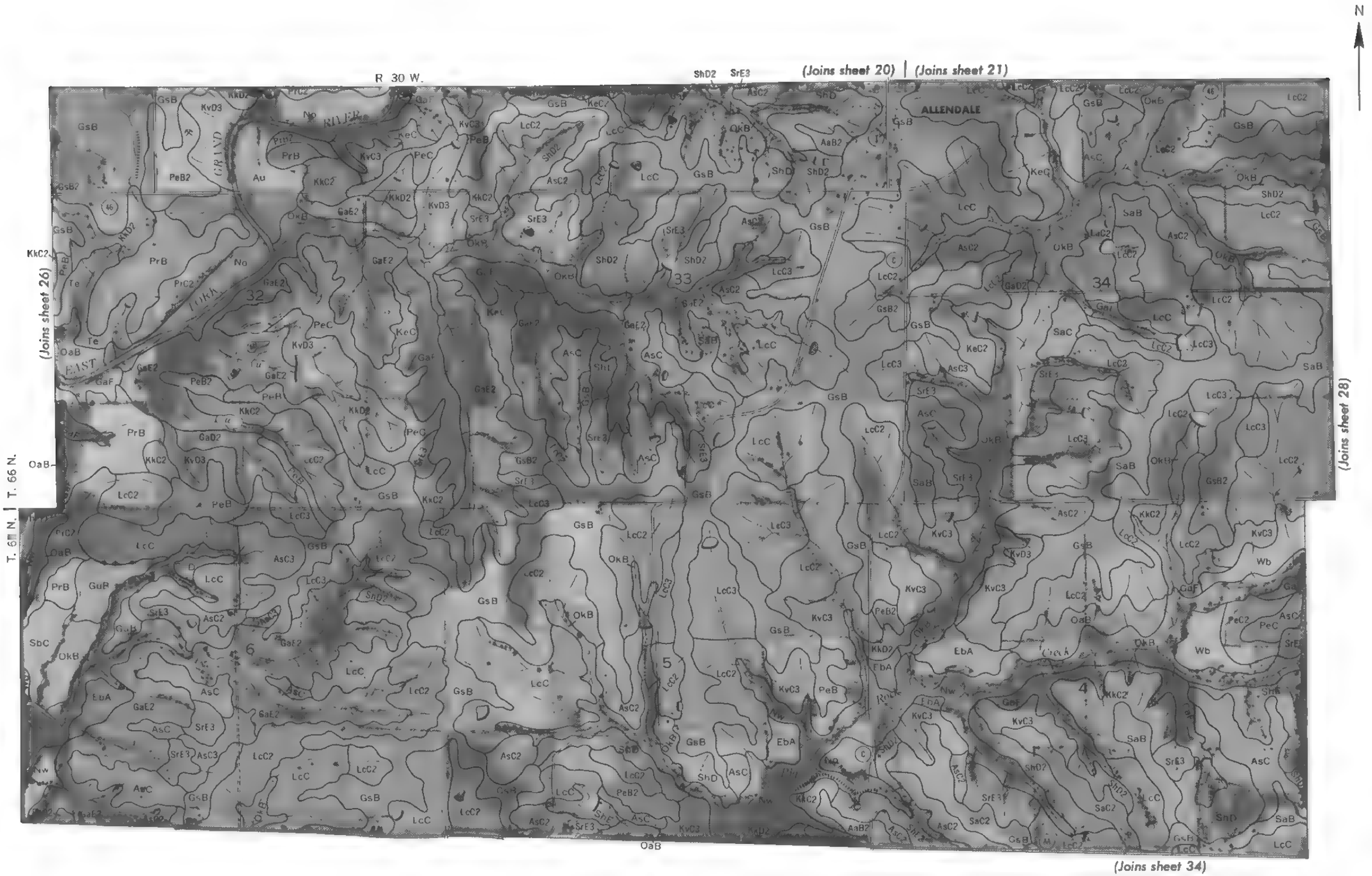

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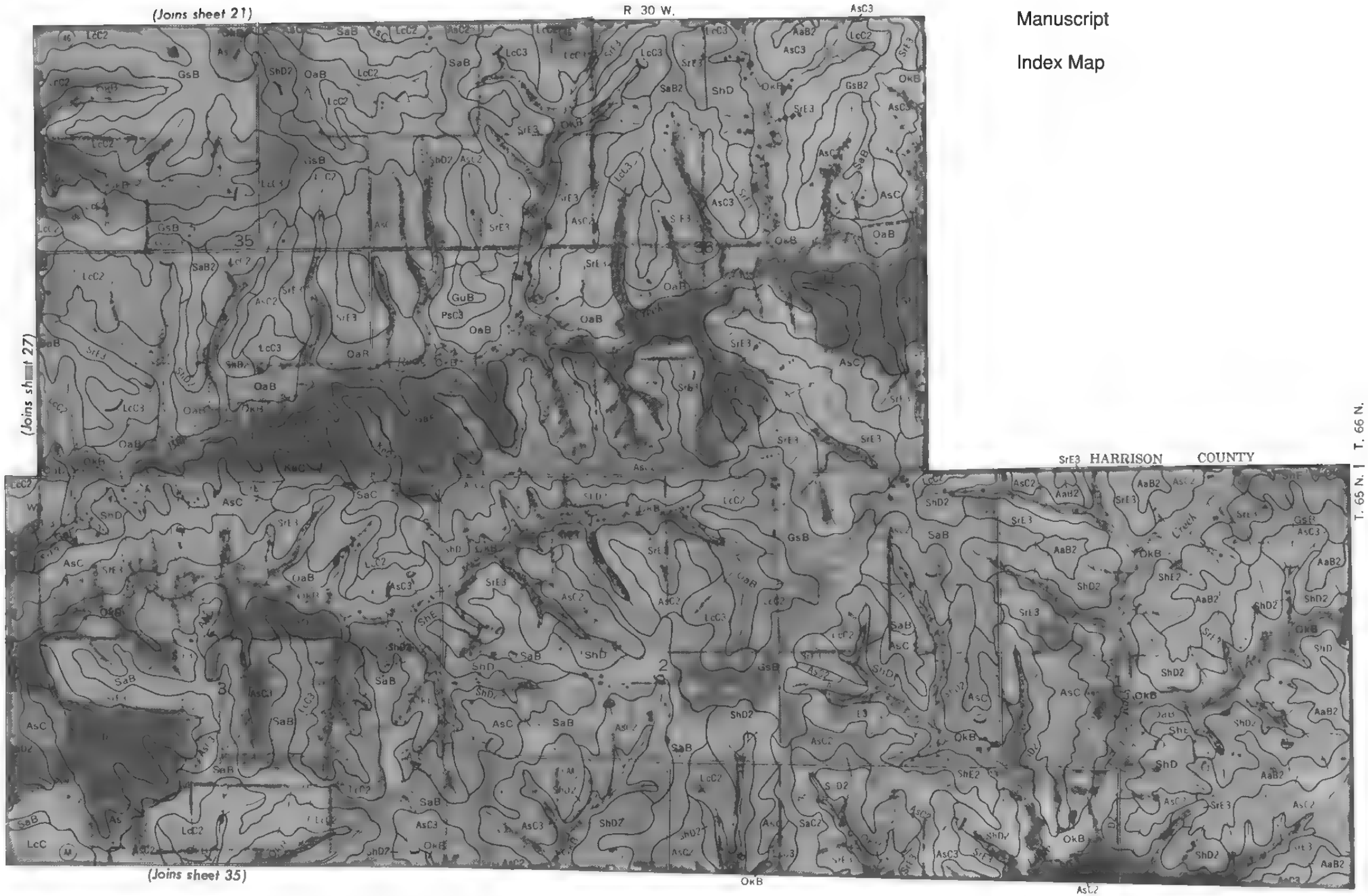

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0 ½ Mile Scale 1 : 15 840 0 3 000 Feet

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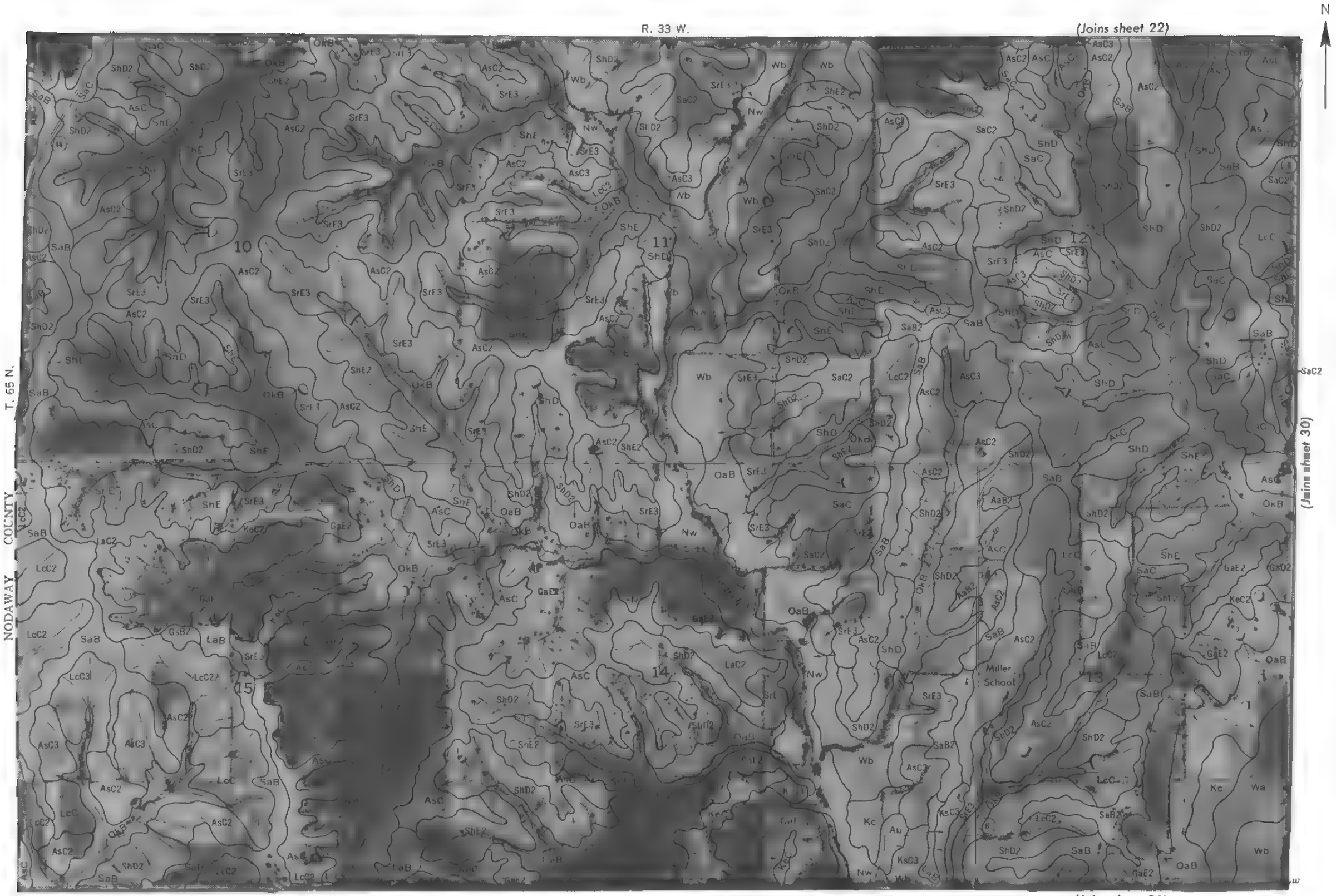

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WORTH COUNTY, MISSOURI — SHEET NUMBER 30

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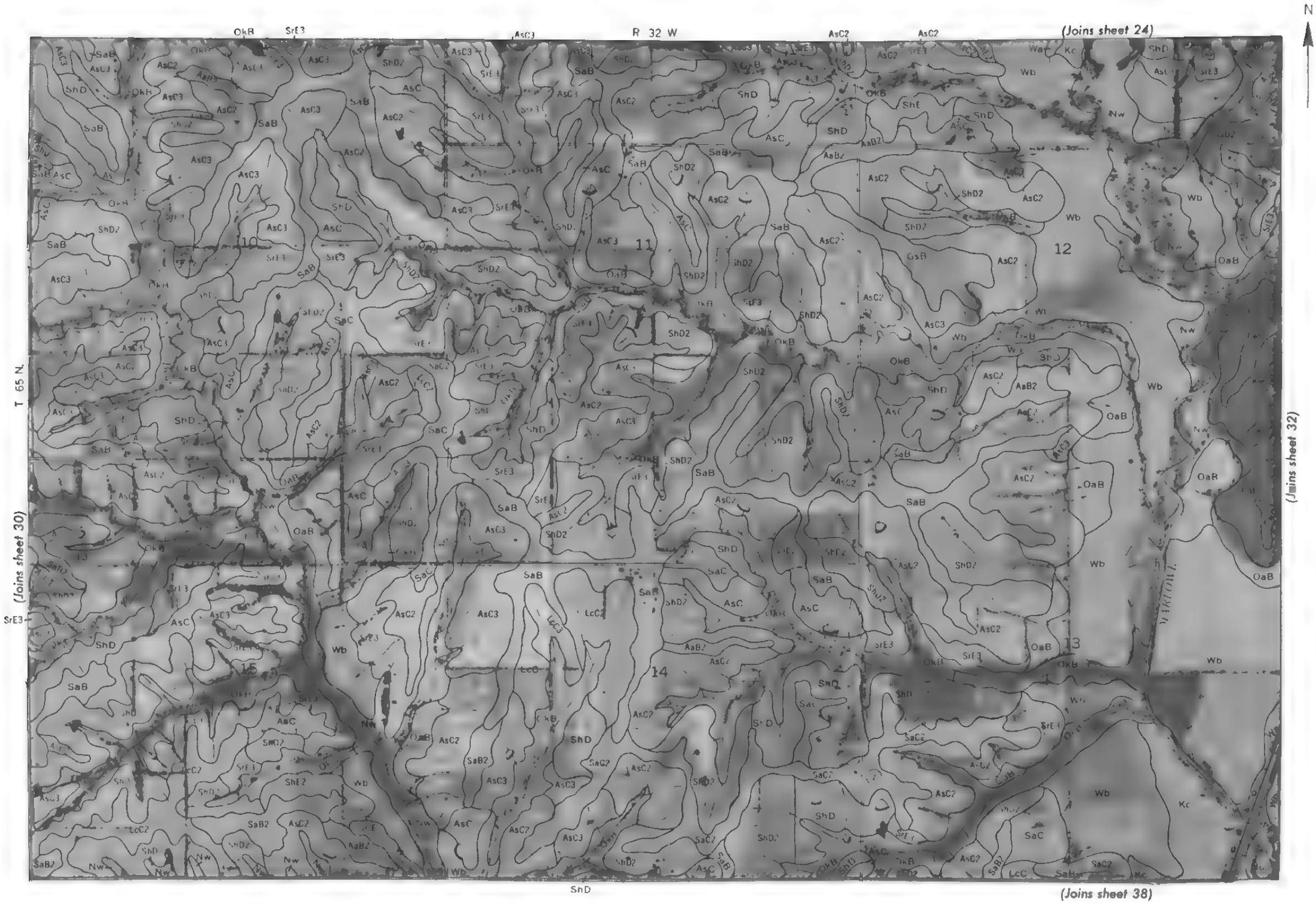

WORTH COUNTY, MISSOURI — SHEET NUMBER 32

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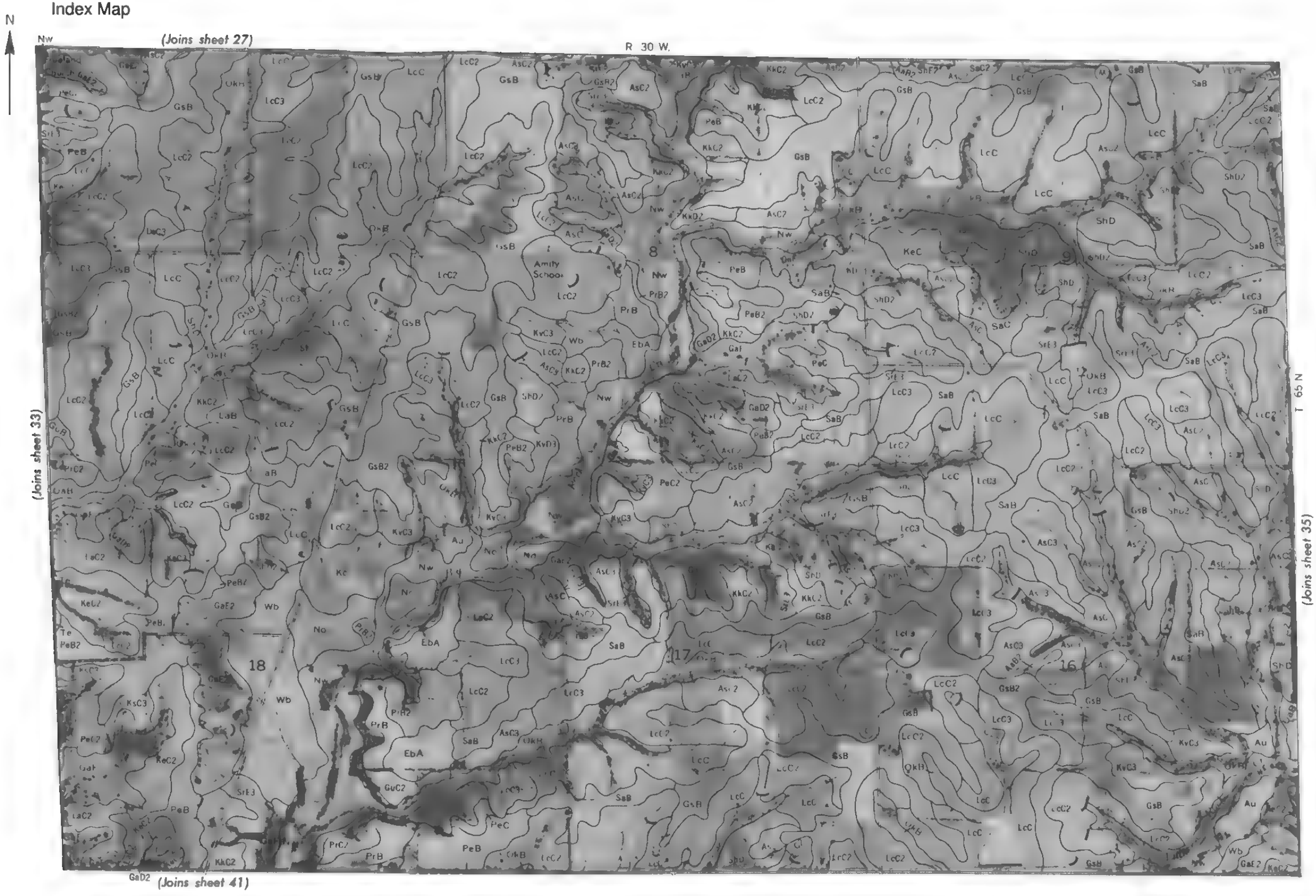

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WORTH COUNTY, MISSOURI — SHEET NUMBER 36

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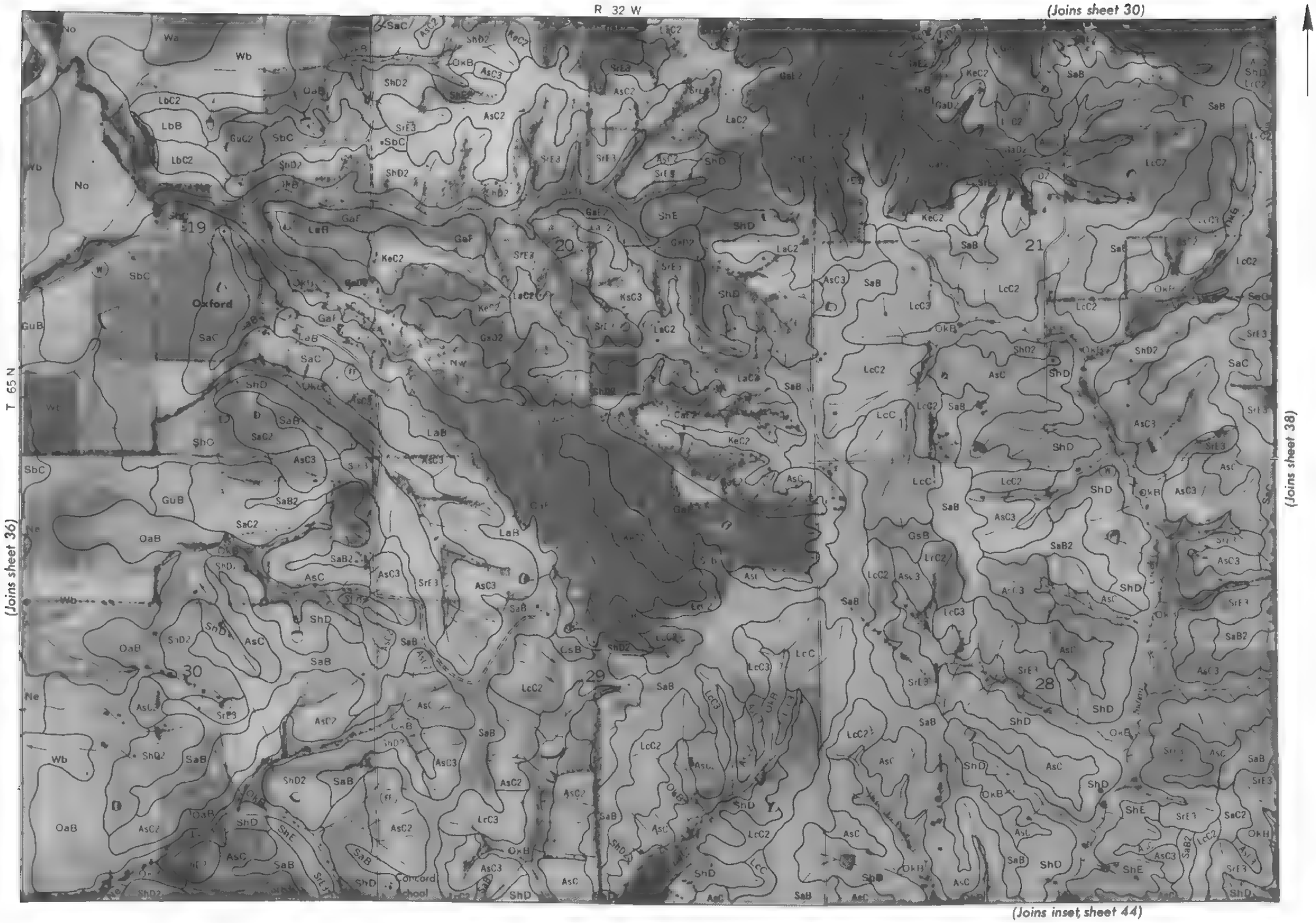

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WORTH COUNTY, MISSOURI — SHEET NUMBER 38

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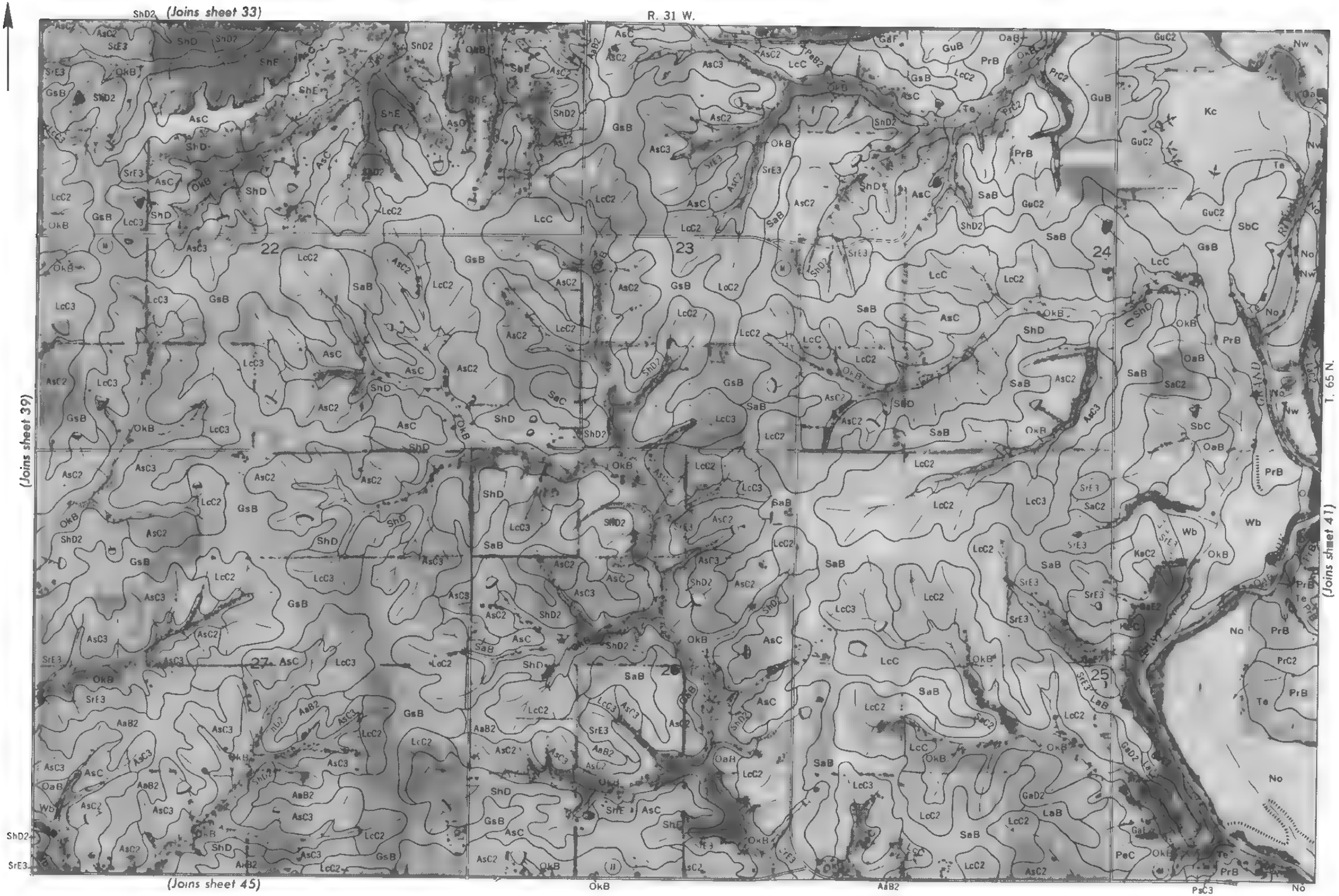

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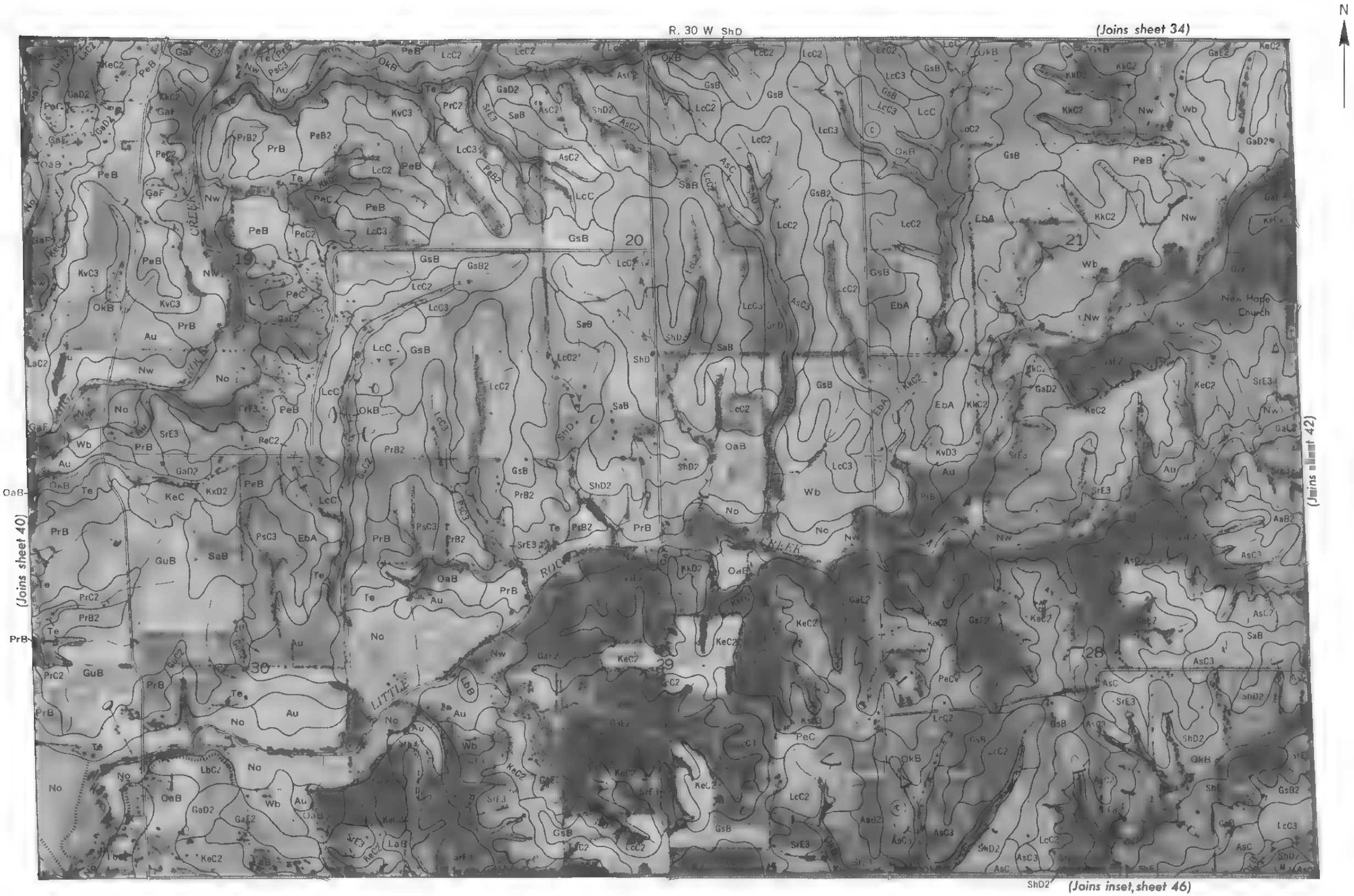

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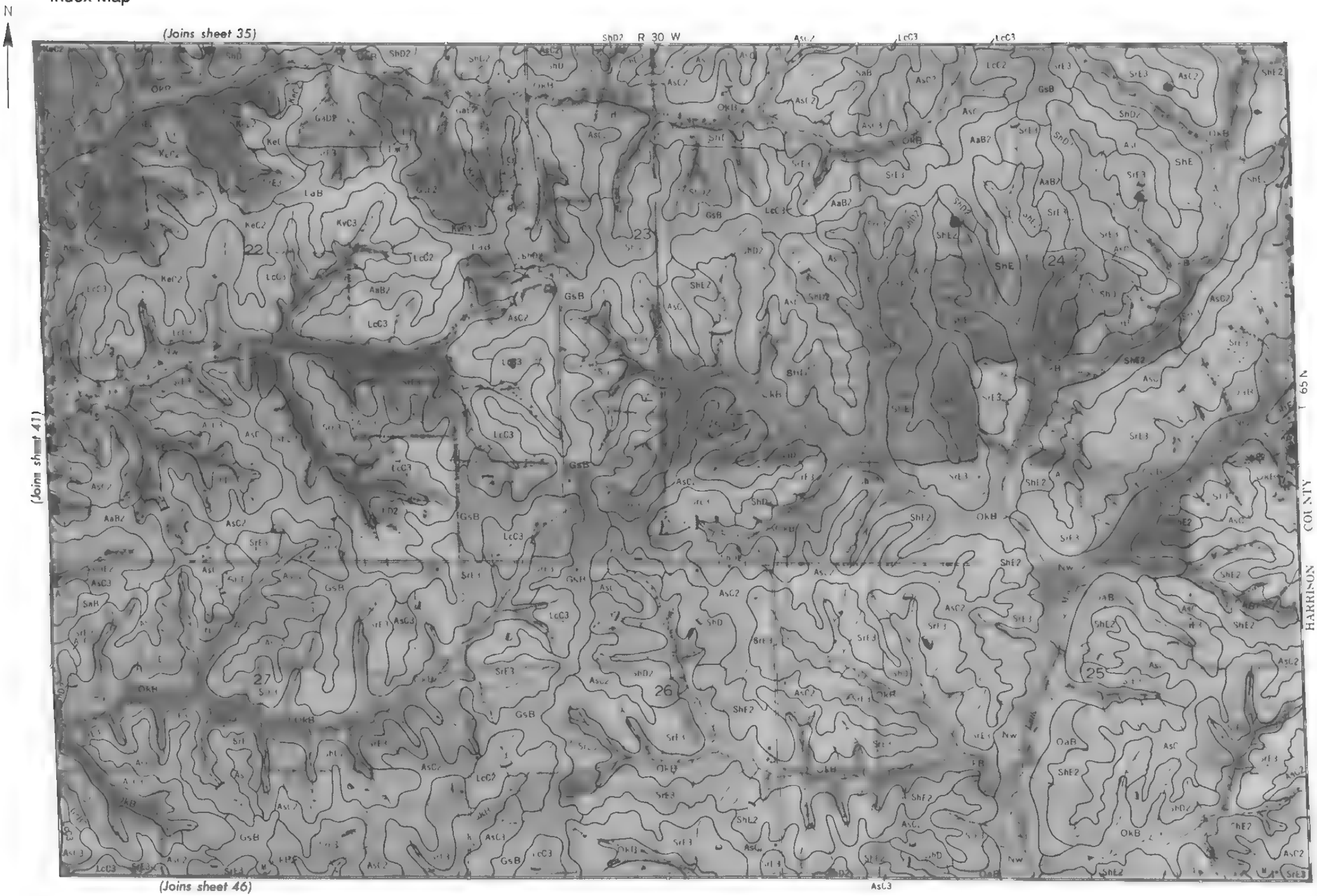

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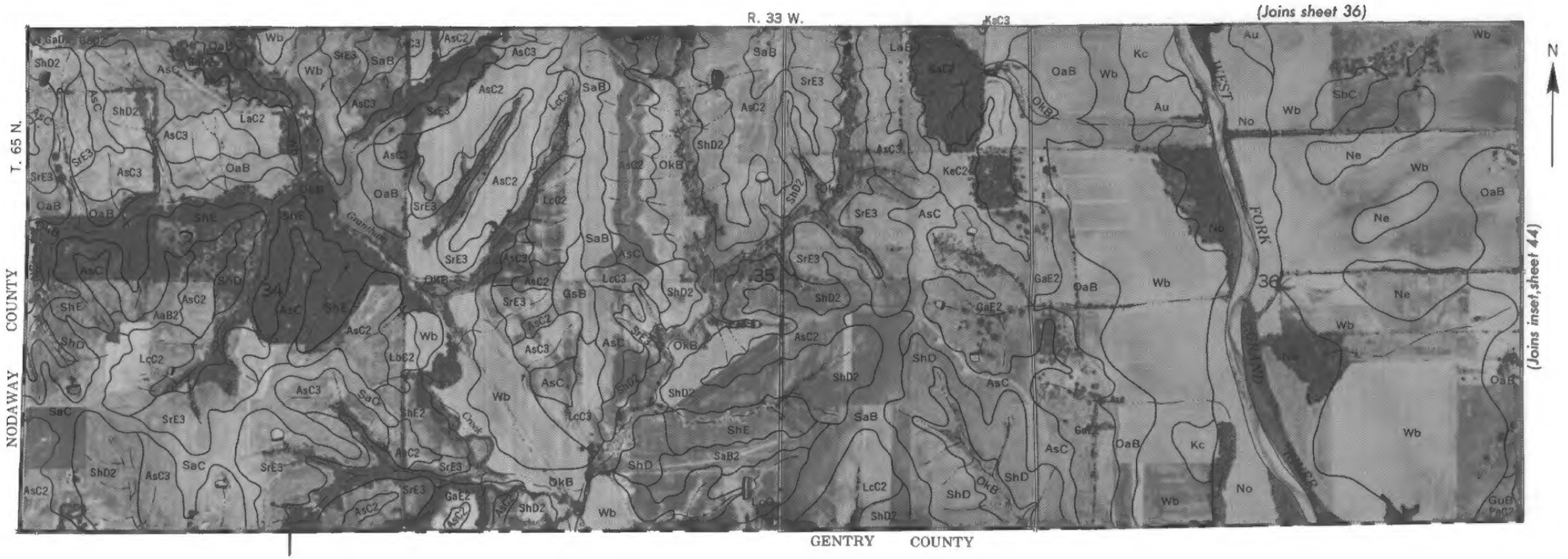

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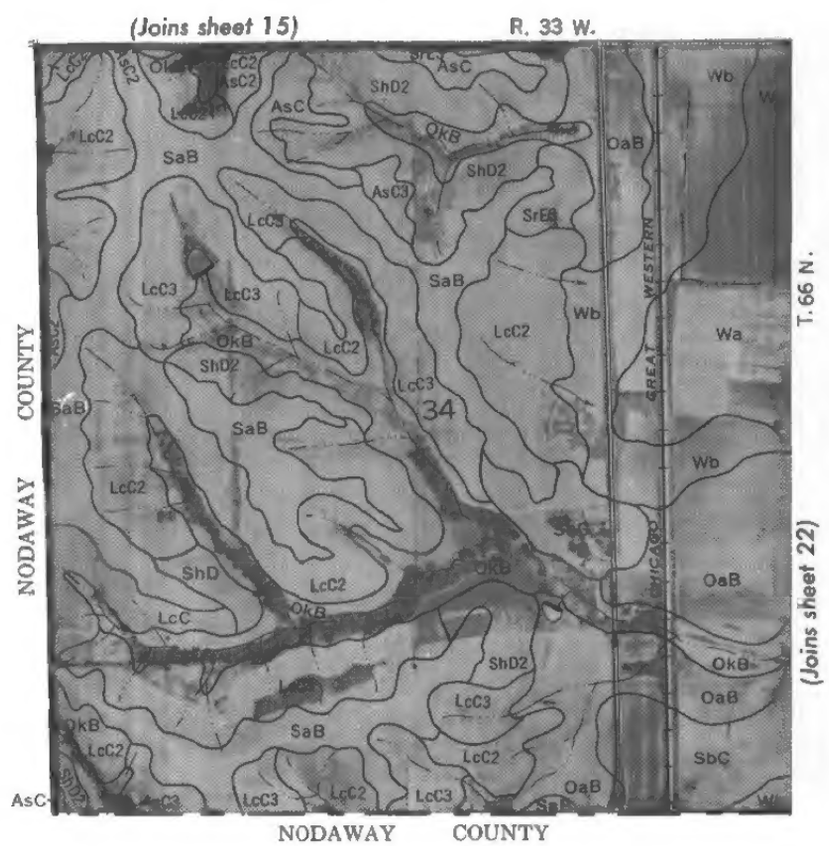

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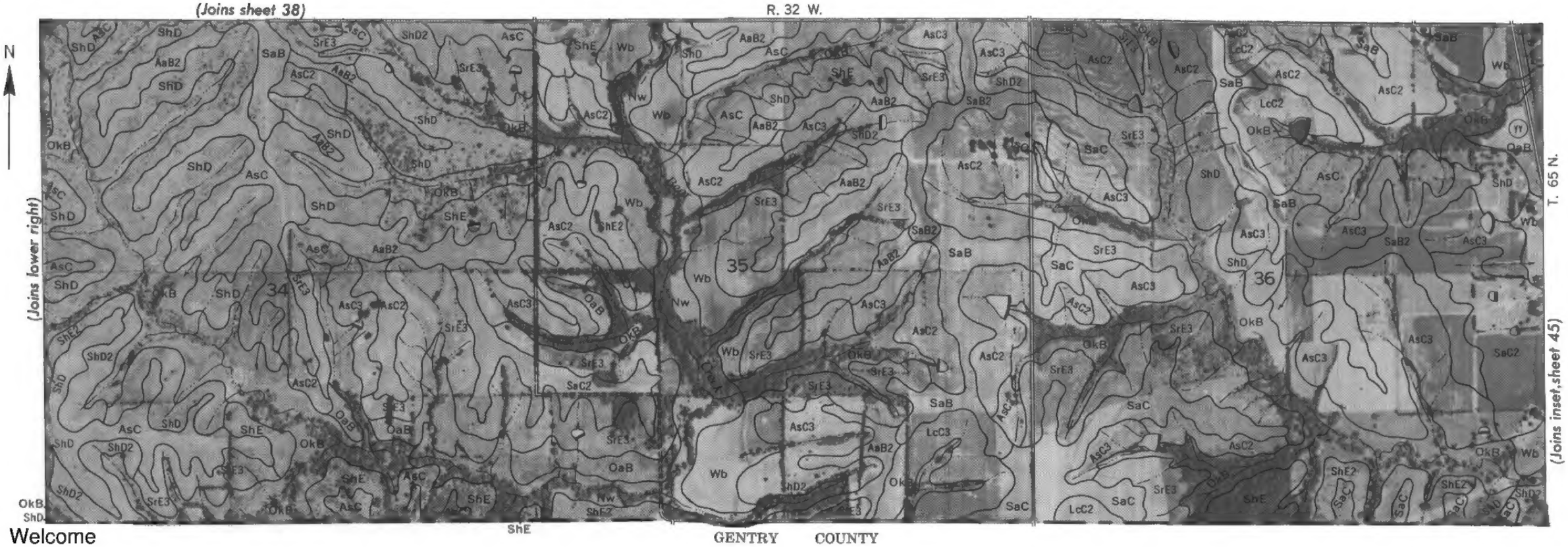

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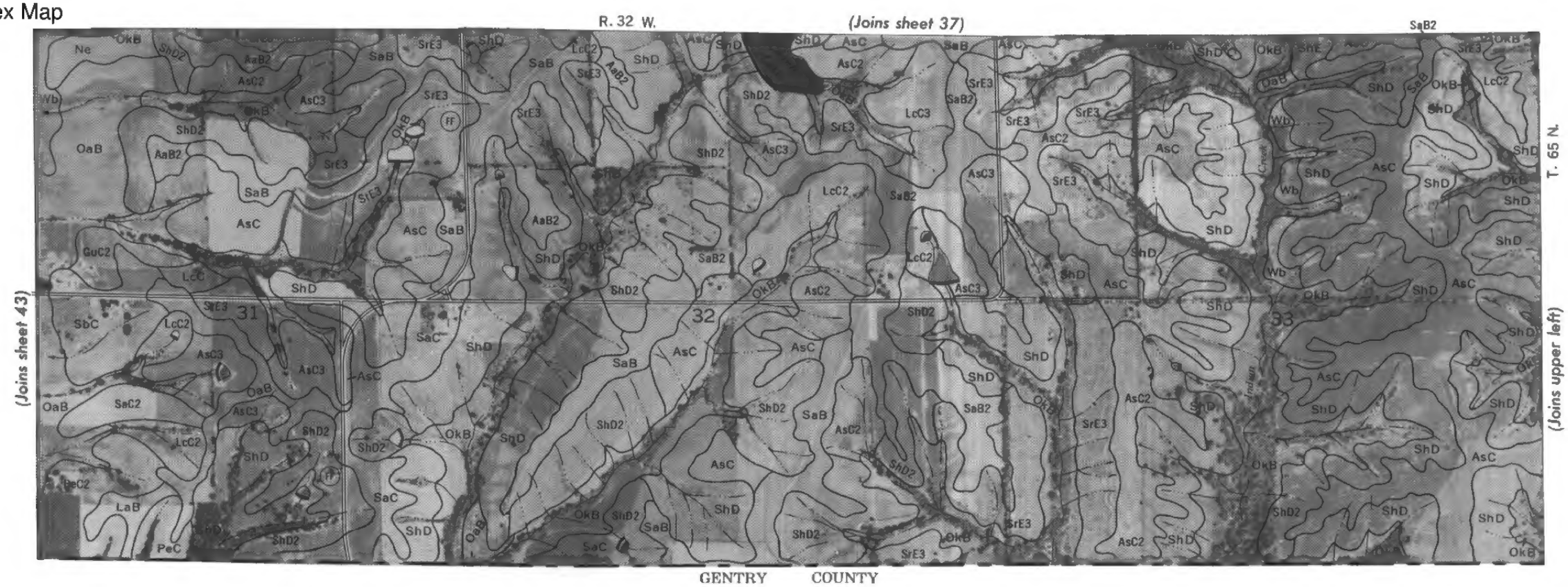

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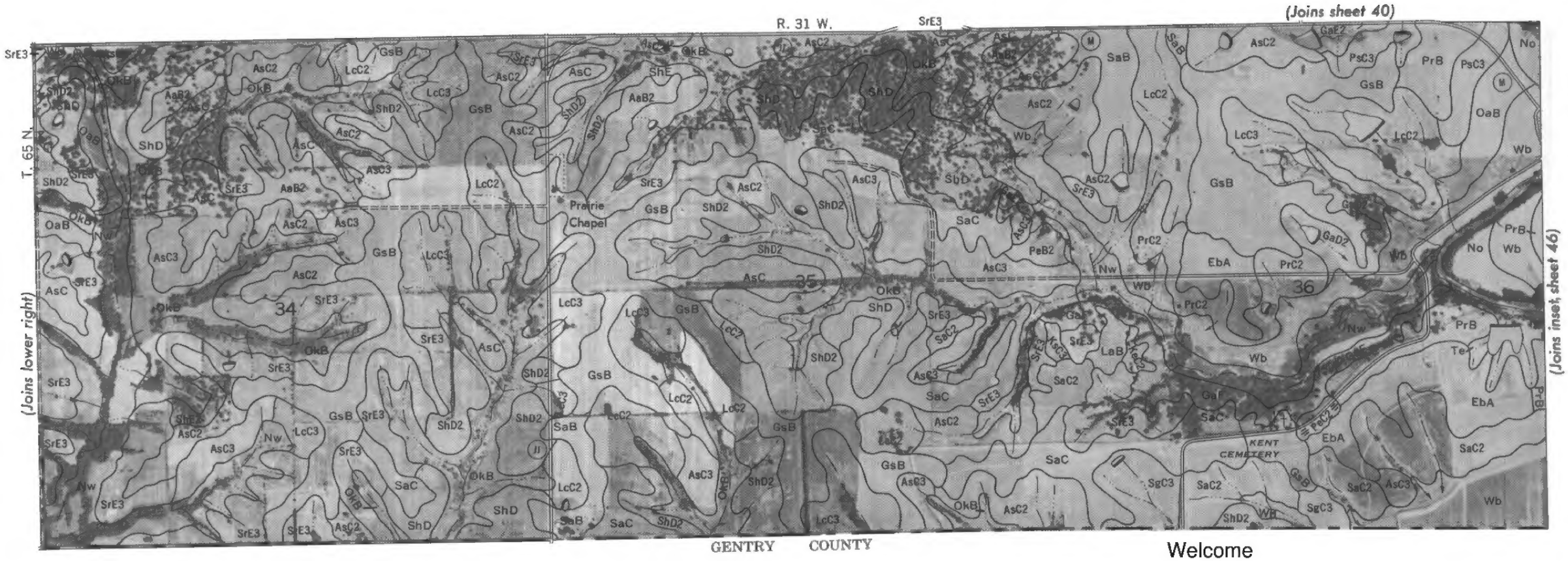

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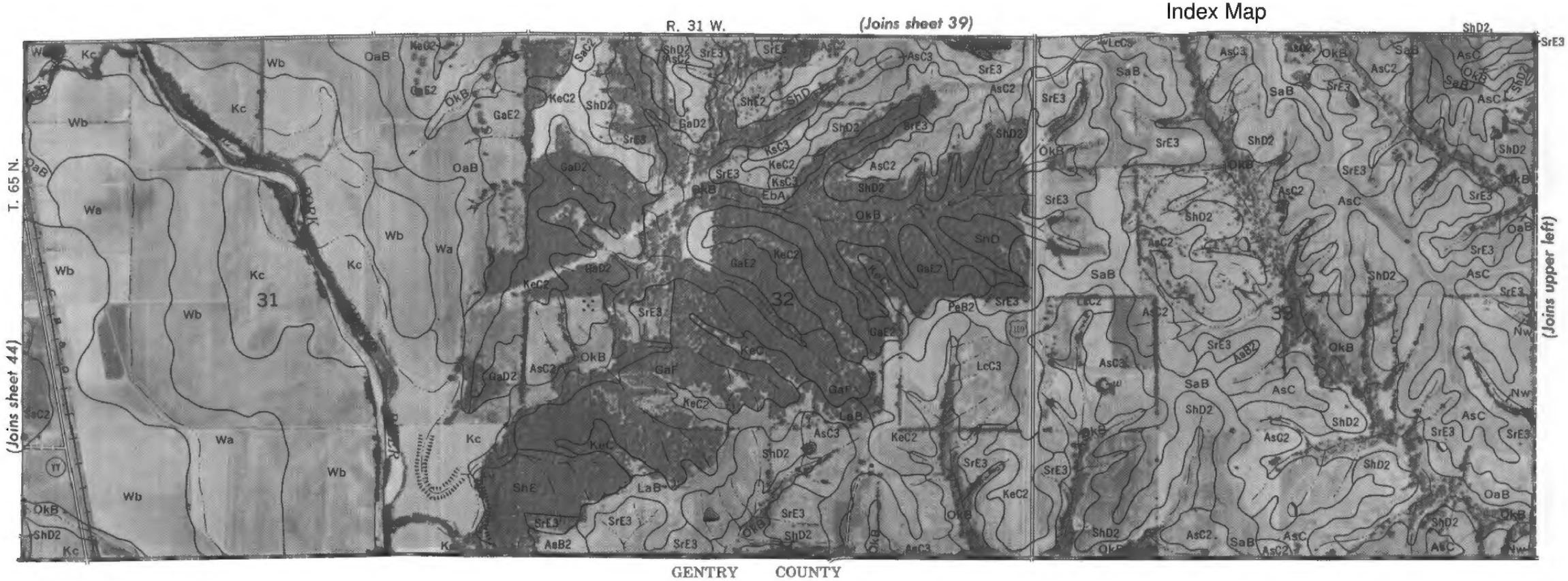

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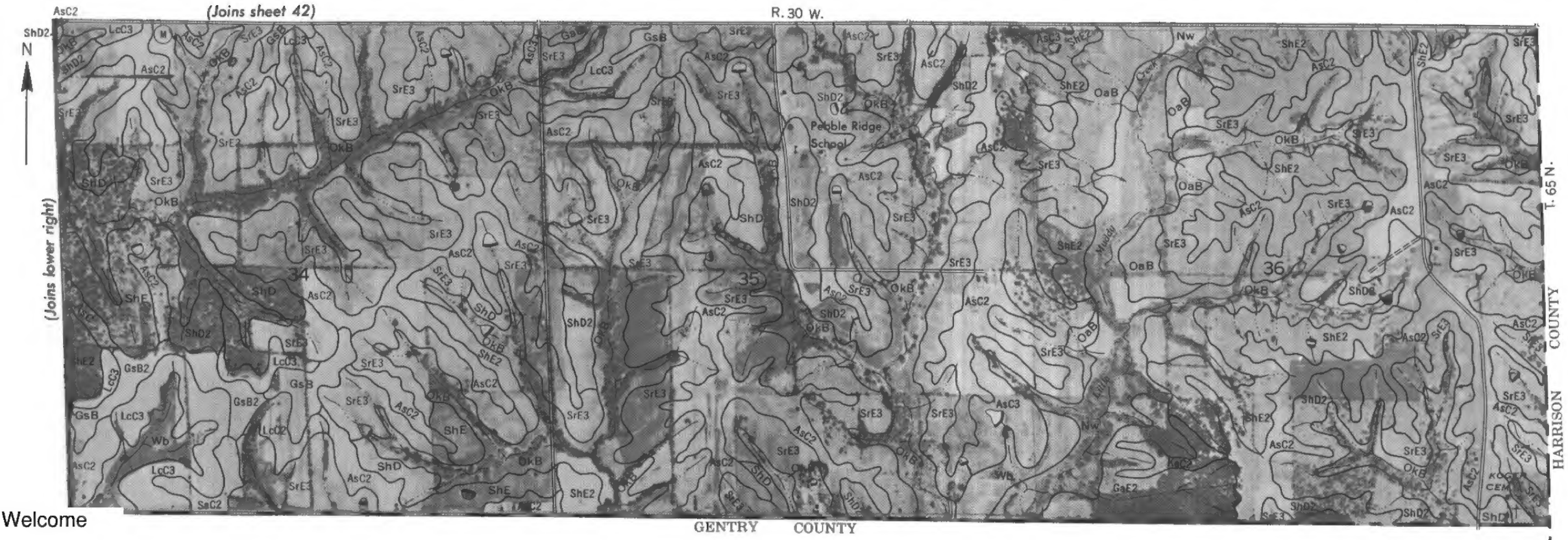

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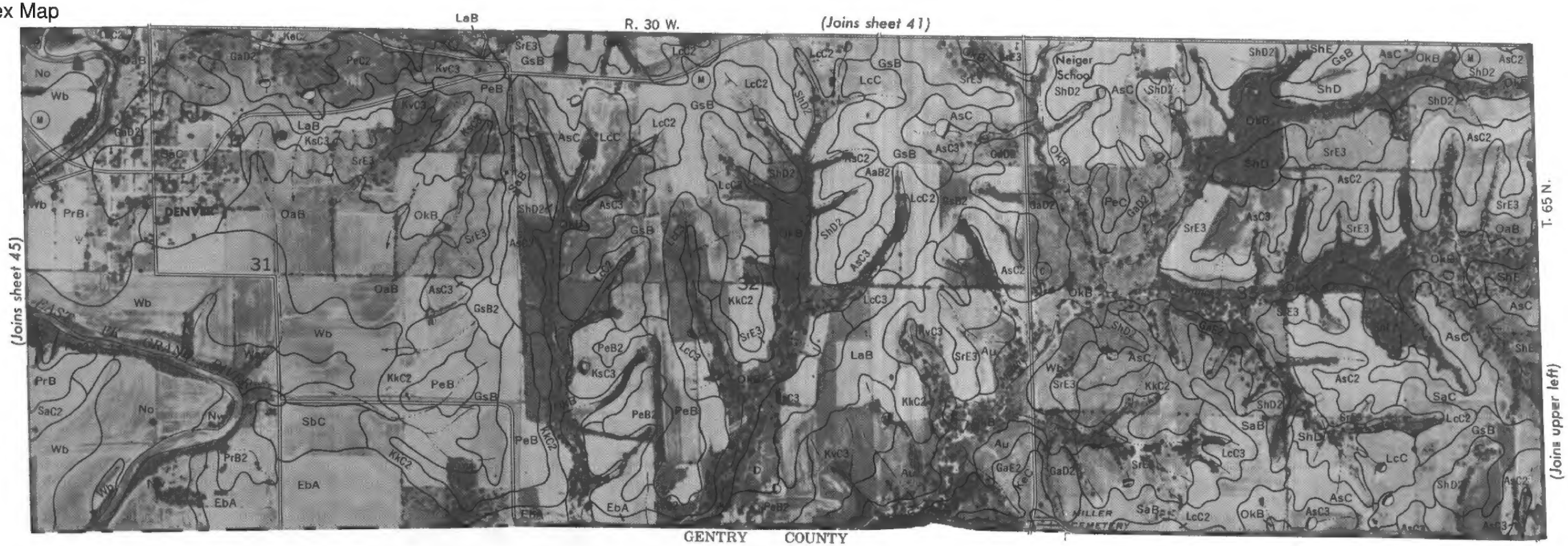

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